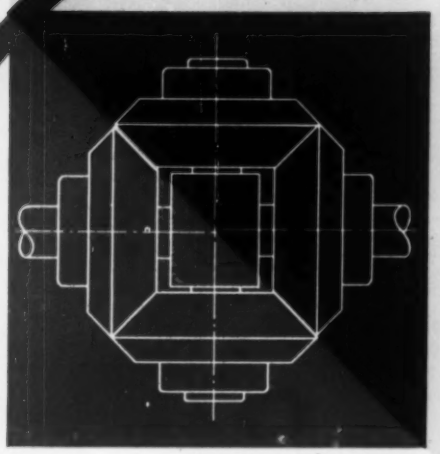
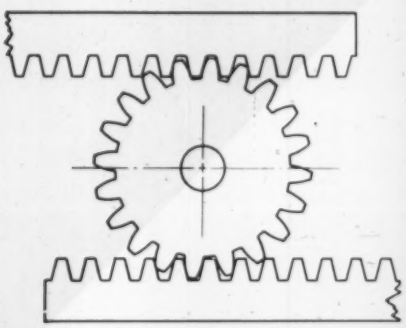
MARCH 19, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Analog Computer Mechanisms



Continued on Page 3

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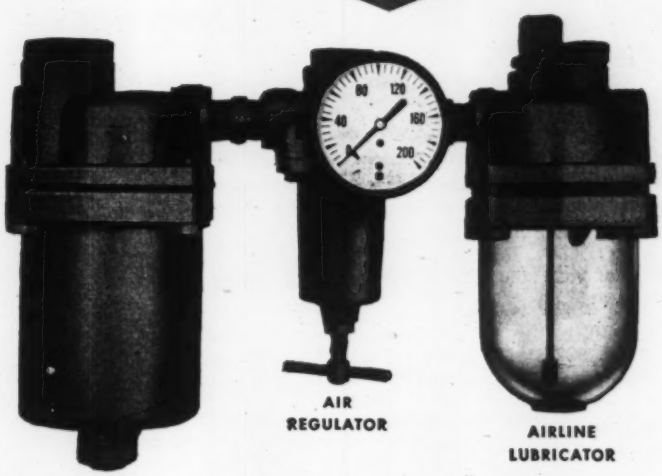

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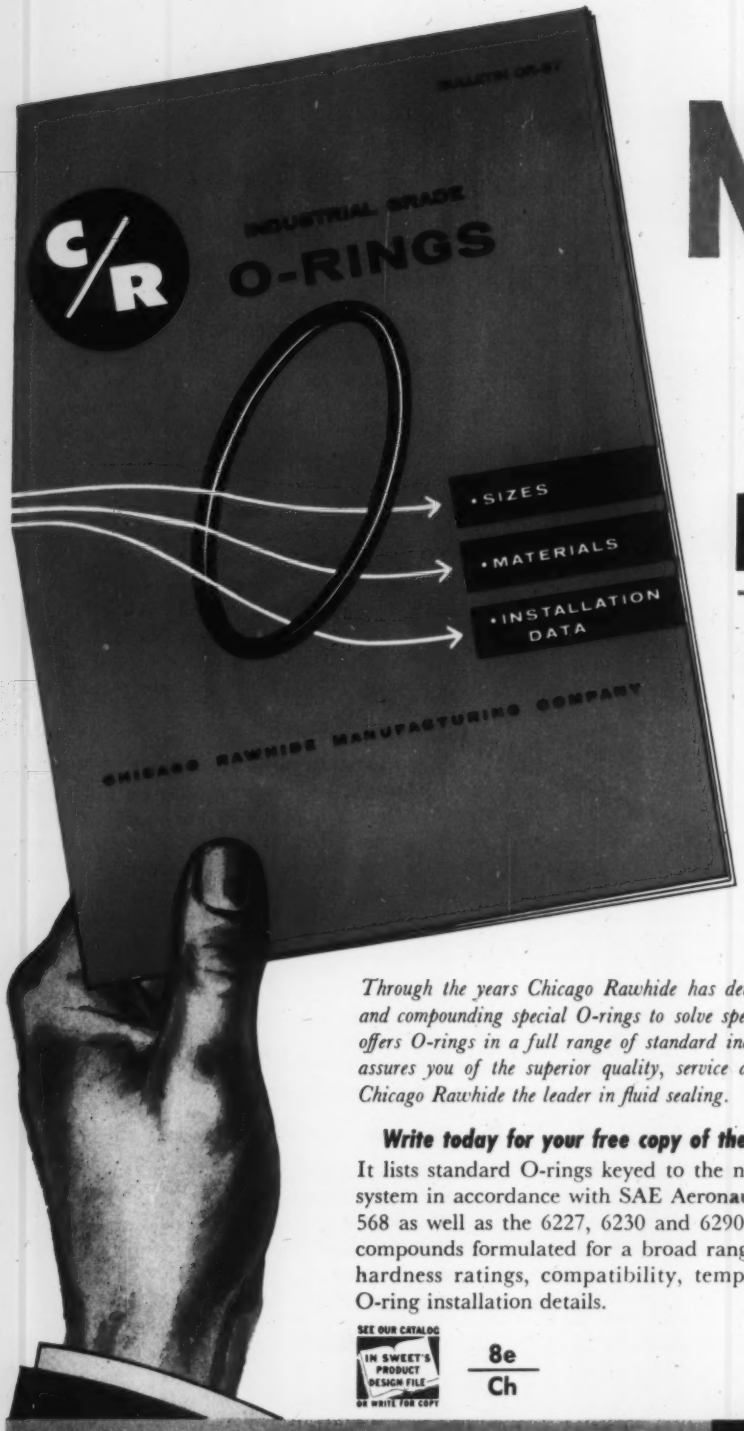

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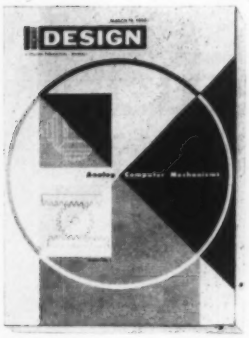

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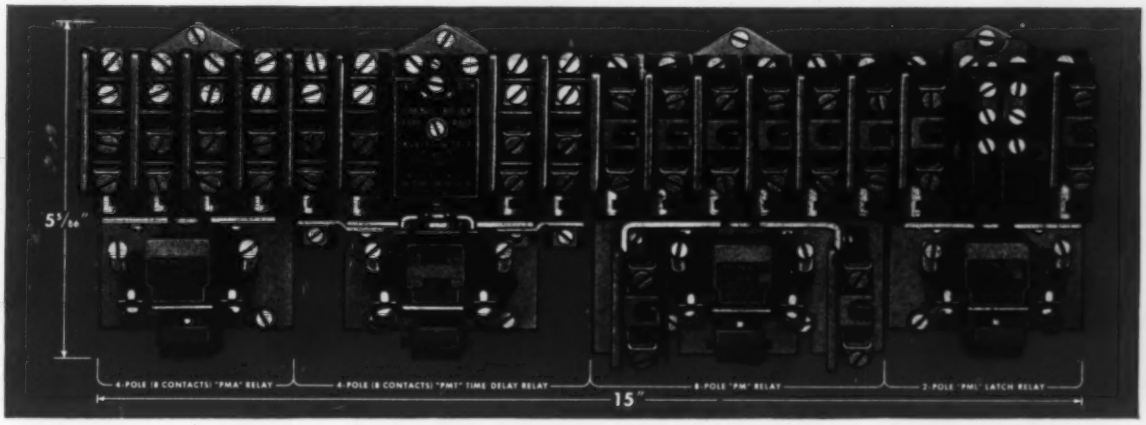

UNIVERSAL POLE RELAYS

up to 14 contacts per relay

New Clark Universal Pole Relays now double the available number of contacts per relay. Each universal pole contains two isolated contacts—one normally open, one normally closed. Melamine barriers and spacing provide 600-v clearance between contacts. Contacts have 10 ampere rating and wiping action. Universal poles are interchangeable with convertible poles of "PM" relays.

Line up with other Clark relays on a panel!

TIME DELAY RELAYS

2 or 4 timed contacts
—up to 6 instantaneous contacts

New Clark Pneumatic Time-Delay Relays match physically other relays in the "PM" line. Timing head occupies the space of 2 poles above magnet. Universal poles each have isolated normally open and normally closed contacts, with 600-v clearance. Timed and instantaneous poles are identical. Available for "ON-DELAY" or "OFF-DELAY" operation (time delay after energization or de-energization), and easily convertible.

Line up with other Clark relays on a panel!

CONVERTIBLE POLE RELAYS

2 to 12 poles

The original line of space-saving control relays featuring exclusive Clark "modular construction". Revolutionary design provides 10 standard units with 2 to 12 poles, from 5 basic models. Stocking of relays and spare parts is greatly simplified. Poles are easily converted from normally open to normally closed and vice-versa. Individual poles are front removable without disturbing wiring.

Line up with other Clark relays on a panel!

LATCH RELAYS

2 to 10 poles

New Clark mechanically-held, latched-in relays have same modular design as "PM" relays—with latch unit occupying the space of two poles above magnet. No increase in height—saving panel space. Latch unit has its own continuous duty coil, allowing one more pole for circuit use since a relay pole is not needed to cut out coil when energized for sustained periods.

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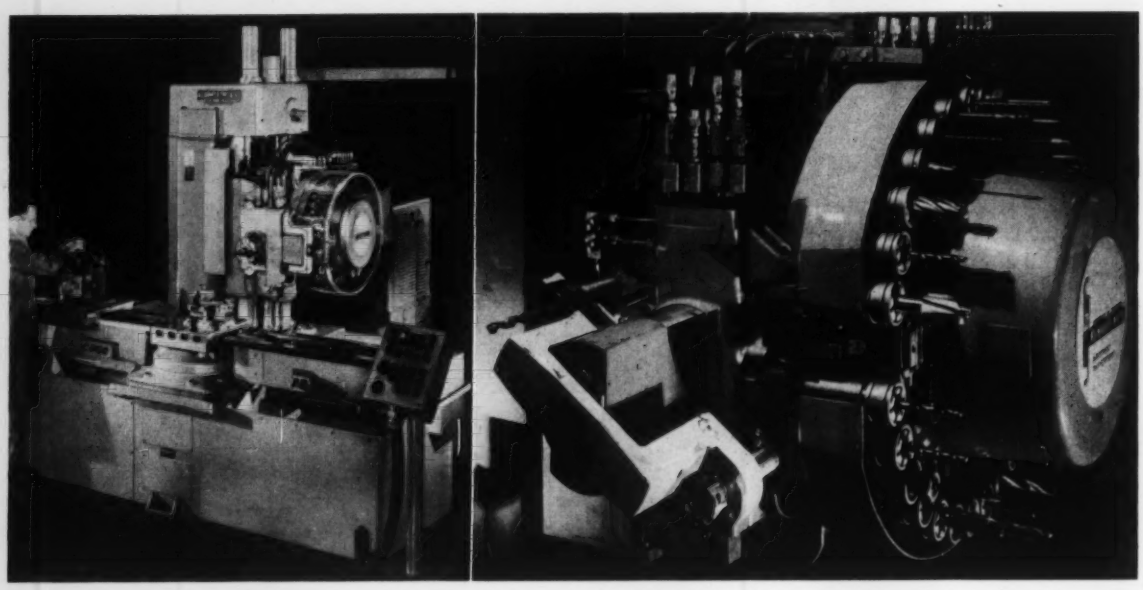
ENGINEERING NEWS



Tape-Run Machine Selects, Chucks Tools on Spindle

From rough blank to finished part in one operation may be possible using this magazine-loaded, tape-programmed shop machine. It drills, reams, mills, and spot faces, following directions on punched tape to change tools and establish position, depth of cut, and dimensions. Thirty tools can be preloaded into the magazine, besides one on the spindle. Here's the sequence that selects and changes tools: As the magazine rotates, feelers identify tools by grooves in the collets. When the proper collet brushes the feelers, a signal stops the magazine; tool and changing arm swivel out at right angles. The changing arm rotates 90 degrees to clamp collets of replacement tool and tool on spindle. It lifts both tools simultaneously from their sockets and rotates 180 degrees to interchange them. After lowering the tools in their new locations and rotating 90 degrees to rest position, the changing arm swivels out of the way. Kearney & Trecker, Milwaukee, claims its machine will reduce the cost of job lots as small as 25.

Engineers Lose Salary Edge 5 to 10 Years After Graduation

EVANSTON, ILL.—Fat starting salaries paid recent engineering graduates have failed to keep them ahead in the long-range income race.

As shown in the annual salary survey conducted by Dr. Frank S. Endicott, Northwestern University's director of placement, the average 1958 salary of a class of '48 engineer was lower than those of his nonengineer classmates who went into accounting, sales, or general business. Except as compared to sales, 1953 engineering graduates seem to be holding their own, but another five years apparently will find them at the lower end of the scale. Relationships of average salaries are:

Field	Class	1958 Avg. Salary
Engineering	1953	$651
	1948	806
Accounting	1953	618
	1948	839
Sales	1953	683
	1948	924
General Business	1953	638
	1948	861

The Endicott Report also indicates that 184 of the companies surveyed will hire 6762 engineering graduates in 1959, compared to 5866 in 1958. Average starting salary will be $480. Some nonengineering starting rates are: Accounting, $422; sales, $419; general business trainees, $413; other fields, $438.

Yesterday's Standards Called Inadequate for Space Age

Reports on Reliability Indicate Need for Change

PHILADELPHIA — Lemons on the launching pad cannot be tolerated with the same equanimity as failure of an appliance or an automobile. In fact, many of the old reliability standards are proving inadequate for products of the Space Age. Suggestions for improving standards and techniques for applying them were outlined recently by an industrialist and a team of reliability engineers, speaking to members of the Franklin Institute and the IRE.

Citing missile failures and U. S. consumers' $20 million annual re-

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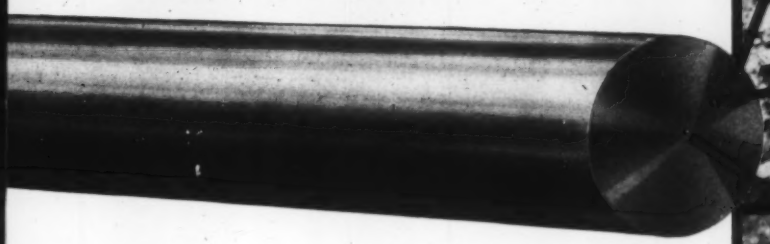

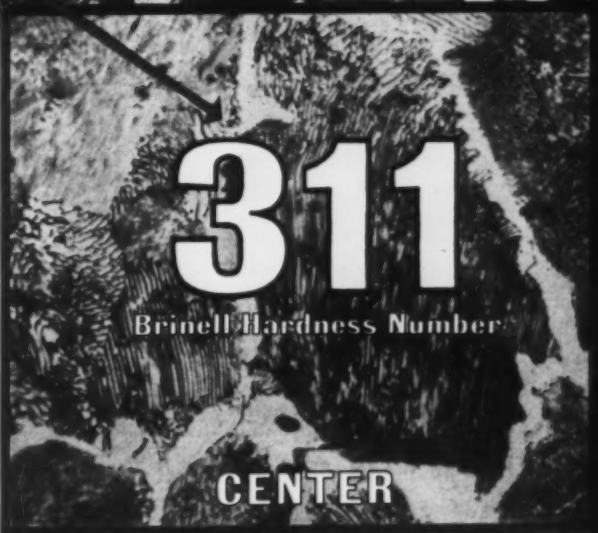

The microscope shows the uniformity of FATIGUE-PROOF. Its uniformly pearlitic structure parallels its uniformity of properties from the surface to the center of the bar.

FATIGUE-PROOF strength and hardness are developed by "e.t.d." (Elevated Temperature Drawing). Unlike quenching and tempering, its effect is the same from surface to the center of the bar. It works a large bar as uniformly as it does a small bar.

There is no mass effect.

The microscope proves it. Surface, center, or mid-radius, FATIGUE-PROOF is pearlitic. There are no mixtures of bainite, martensite, and pearlite. FATIGUE-PROOF is uniform bar to bar, size to size, and lot to lot.

T. M.—Trade-marks of La Salle Steel Company

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Circle 407 on Page 19

pair bill, H. Thomas Hallowell, president of Standard Pressed Steel Co. and former head of the American Standards Association, attacked the increasingly intolerable and expensive situation of unreliability.

First steps toward improvement

Speaking to members of the Franklin Institute, Mr. Hallowell recommended the following as immediate steps toward solving the problem:

- An added budget of $90 million (the cost of only three Atlas missiles) for the National Bureau of Standards, enabling it to tackle badly needed studies on basic standards and new techniques for testing and measuring in industry
- A major national symposium on the subject of new standards for reliability, to be sponsored by the Franklin Institute and held in the fall of 1959
- A review of existing industrial standards of quality which, in many cases, are grossly inadequate.

As an example of outdated manufacturing standards, Mr. Hallowell noted that the industry-wide acceptable quality level for fasteners is 2.5 per cent; that is, a shipment with that percentage defective is acceptable and will be used. While 97.5 per cent "good" parts may seem high, he pointed out that a 100-part assembly with components of this order of reliability would have only one chance in 12 of doing its job.

Even the 99 per cent reliability required for many parts used in aircraft and missiles would produce, on the average, two failures out of every three attempts with a 100-part mechanism.

New: Reliability engineering

Techniques of a new professional field—aimed at uniformly greater reliability in complex weapons and space-vehicle and missile equipment—were outlined recently by five Sperry Gyroscope Co. reliability engineers to members of the Institute of Radio Engineers Professional Group on Military Electronics. They emphasized these advanced methods of reliability engineering:

- Treatment of environment severity as a measured "input signal" operating on all missile or space-borne electronic equipment
- Analysis of equipment weight and strength as "mechanical overhead" factors that can penalize weapon performance
- Greater use of the high-speed electronic computer as a major tool for decision-making in complex reliability analysis.

1000-hp Model Airplane

One of the biggest windtunnel models ever built will help determine best designs for Army VTOL and STOL aircraft. Built by Vertol Aircraft Corp., the huge model has a 35-ft wingspan, an over-all length of 27 ft, and weighs 14,000 lb. It has the general configuration of a transport aircraft and combines deflected slipstream and tilt-wing design concepts. (Full-scale aircraft using both of these designs have been successfully flown.) Propellers are driven by a 1000-hp variable-frequency electric motor mounted in the fuselage. Shafting between propeller gearboxes can be disconnected for tests with two, four, or six propellers. Wingtip panels are also detachable midway between the two outboard nacelles to permit testing with four propellers and reduced wingspan.

Topics

Shocking a sailor, by means of electricity, will activate his muscles and may provide exercise not otherwise possible in crowded quarters of a submarine. The medical officer of the atomic-powered submarine *Seawolf* says that submariners' lack of normal exercise may someday be remedied by machines that produce electric shocks, forcing muscles to act. Spacemen, with an even greater exercise problem, may also consider the shock treatment.

• • •

Untouched by human hands, mail processed by a post office in Providence, R. I., will be handled entirely by machinery. One device will separate letters and larger pieces of mail and another will face them in position for high-speed cancelling. Operators at keyboards will control mail-sorting machinery. Project Turnkey, to be built by Intelex Systems Inc., New York, is to be completed in September, 1960.

• • •

D-c driving may come back into style—that nearly extinct little old lady in the Baker Electric is soon to have company as she hums along city streets. Battery-powered cars that travel 70 miles on a charge and have a top speed of 55 mph are being produced by a San Diego firm. And in Cleveland, electric delivery trucks are being built for rental to dairies, bakeries, and utilities. Operating cost of about a penny a mile is predicted for the car.

• • •

Automatic attendant at the New York International Airport parking lot is a Westinghouse Cypak system. As a car approaches the gate, a magnetic coil beneath the road senses its presence and causes the ticket dispenser to stamp the date and time on a ticket. The driver takes the ticket from the machine; meanwhile the system has raised the gate. The gate closes when the car passes over a second magnetic coil. The Cypak system can adapt itself to a steady stream of traffic without danger of gates being dropped on cars.

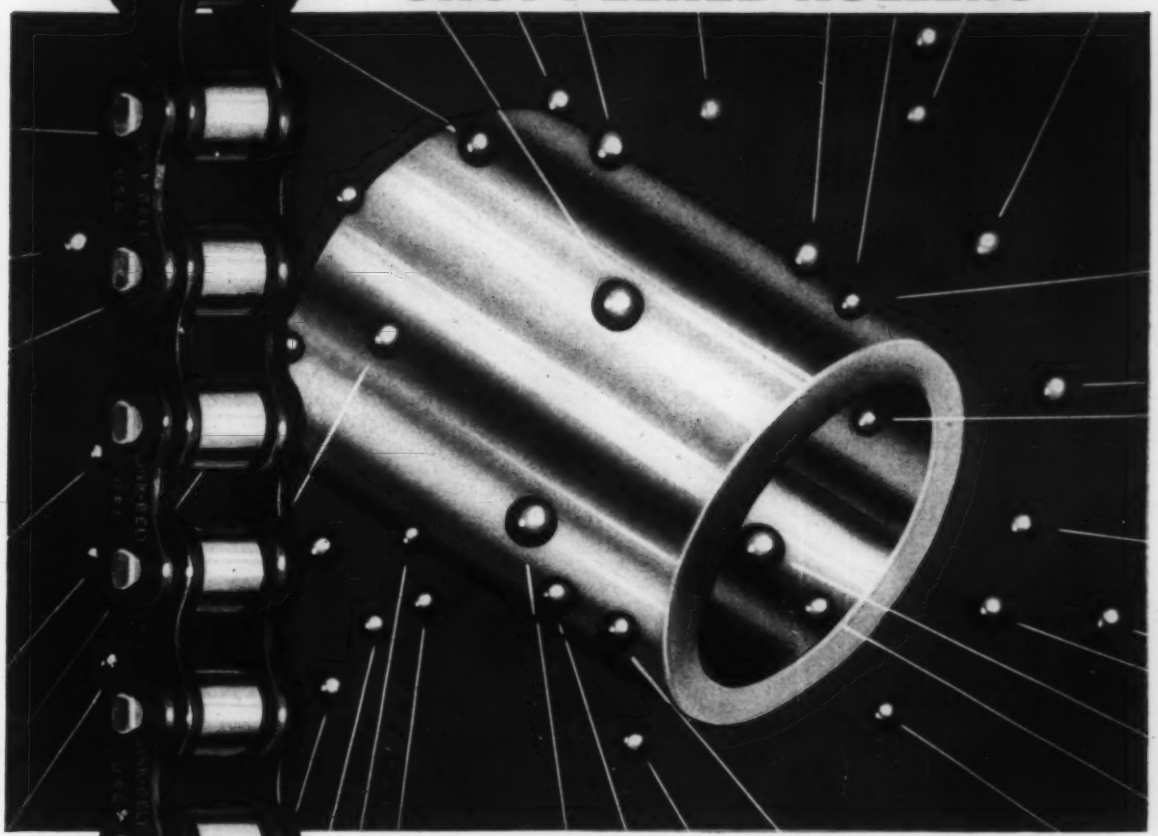
• • •

Soft-ride synthetic, Plioprene rubber is a development of Goodyear Tire & Rubber Co. Tires made of the material reduce vibration, road rumble, and thuds caused by highway joints, according to Dr. R. P. Dinsmore, Goodyear research vice president. He also says the new rubber improves stability and road-holding qualities of tires and reduces squeal when a vehicle rounds a corner or a sharp curve. As yet, Plioprene tires are not available commercially.

Shining example of "extra" chain quality

SILVER-BRITE

SHOT-PEENED ROLLERS



EXTRA LIFE IS POUNDED IN AND NOT POLISHED OUT

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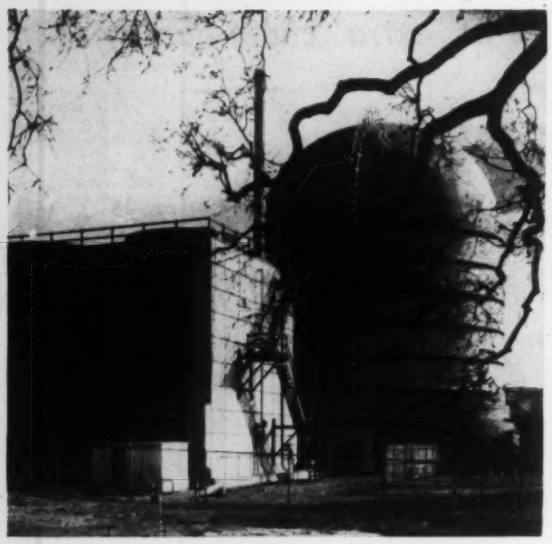
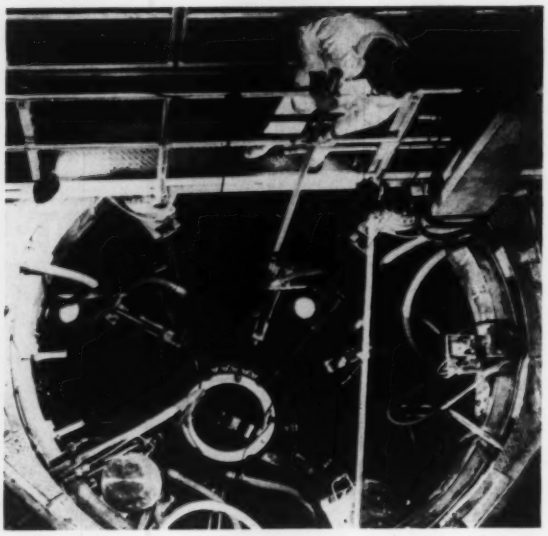
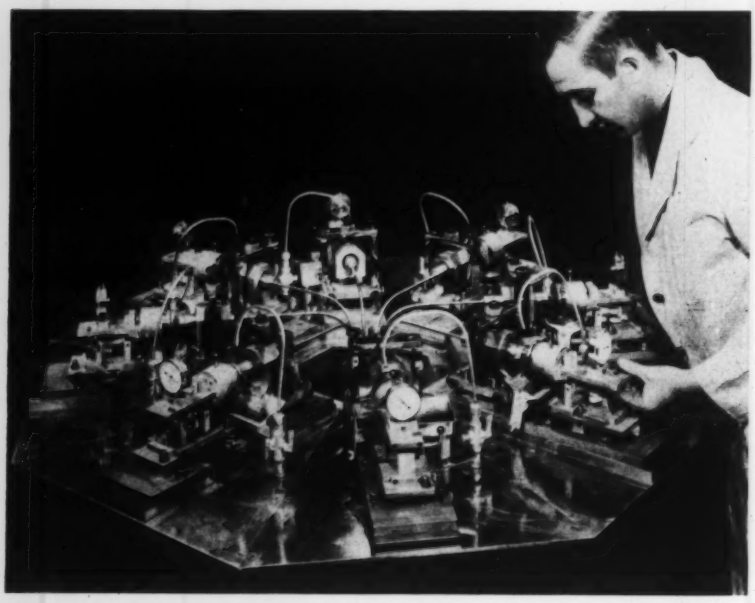




Test Reactor No. 1 Goes Critical

Industry can now contract for neutron and gamma irradiation space in GETR, General Electric's new materials testing reactor at Vallecitos, Calif. Holding AEC test-reactor license No. 1, the privately financed facility has recently been brought to full-capacity power of 30,000 kw (thermal). GETR combines design features of both swimming-pool and tank-type reactors: The reactor core, housed in a 2-ft diam aluminum pressure vessel (circle, right), provides internal loops and capsules for high-level irradiation testing; the surrounding light-water pool serves as a reflector and permits materials testing at lower flux levels. Initially scheduled for irradiation of experimental fuel elements, GETR will be used for GE work and by outside firms in chemicals, electronics, and aviation.



Ultrasonics Piped through Curved Tubing

Single magnetostrictive transducer mounted in the well of a waist-high table transmits 20,000 cps to each of eight machining stations in this ultrasonic machining tool. A remote 1000-w, high-frequency generator drives the transducer. Energy is delivered to work through curved tubing which makes possible machining in many heretofore inaccessible places. The Sheffield Corp., Dayton, Ohio, says the new machine costs about half the price of the eight it replaces.

Radiation-Resistant Tires Ready for Nuclear Plane

BRECKSVILLE, OHIO—At least some of the groundwork in nuclear-aircraft development is proceeding according to schedule. B. F. Goodrich Co. reports production of aircraft tires that are able to absorb moderately strong doses of nuclear radiation and still perform satisfactorily.

Secret of the nuclear tire is an improved "anti-rad," a chemical added to rubber stock before vulcanization to increase rubber's resistance to radiation.

According to Goodrich, simulated landings on a dynamometer tester showed that irradiated tires protected with their new chemical rolled twice as many miles before failure as conventional irradiated tires. The radiation-resistant tires survived 25 high-speed landings, plus "several" low-speed landings. This compares favorably with performance standards set for conventional aircraft tires: 25 high-speed and 150 low-speed landings are considered to be acceptable.

Photo courtesy of The Park Drop Forge Co.

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YOUR FORGING COSTS

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Circle 409 on Page 19

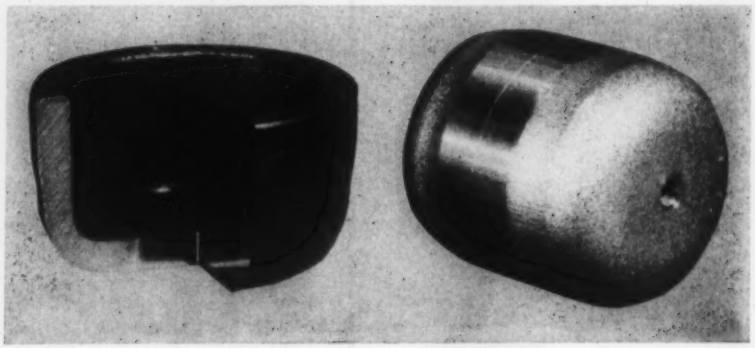
New Method Discovered To Deep-Draw Tungsten

Technique Makes Possible Design for 5000 F Temperature

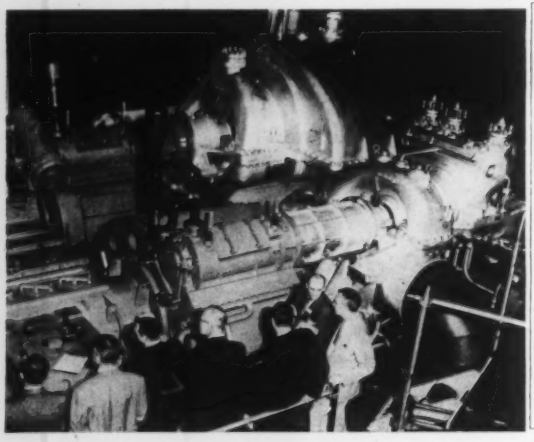
NORTH CHICAGO, ILL.—Rocket nozzles, nose cones, and reactor parts that withstand 5000 F can be made of tungsten using new working techniques announced by Fansteel Metallurgical Corp. Parts that have been forged, rolled, deep-drawn, and spun have been displayed by the company. Many of these parts are "firsts" for the metal.

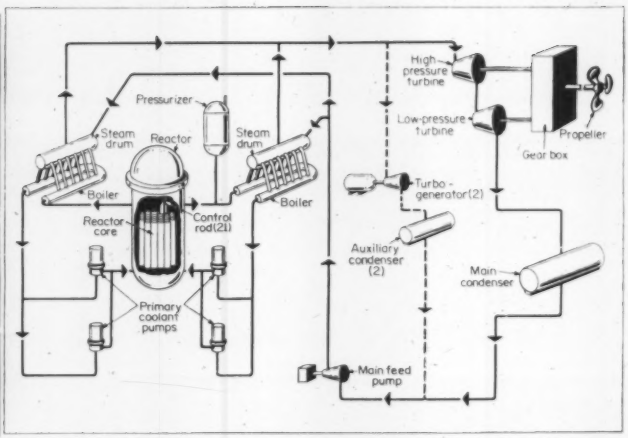
Problem in working the metal has been its otherwise desirable high-temperature properties. Tungsten, with its high melting point, becomes brittle below 750 F. To get the ductility needed for working tungsten even at this fairly cold temperature, it must first be wrought at temperatures that would melt stainless steel. Tungsten is not held very long at these temperatures, and work must be done quickly, because working at temperatures in this range, tools necessarily made of lesser metals do not stand up.

Another new development is seamless-tungsten tubing that has been produced by a hot-extrusion process. Thin walls are possible.



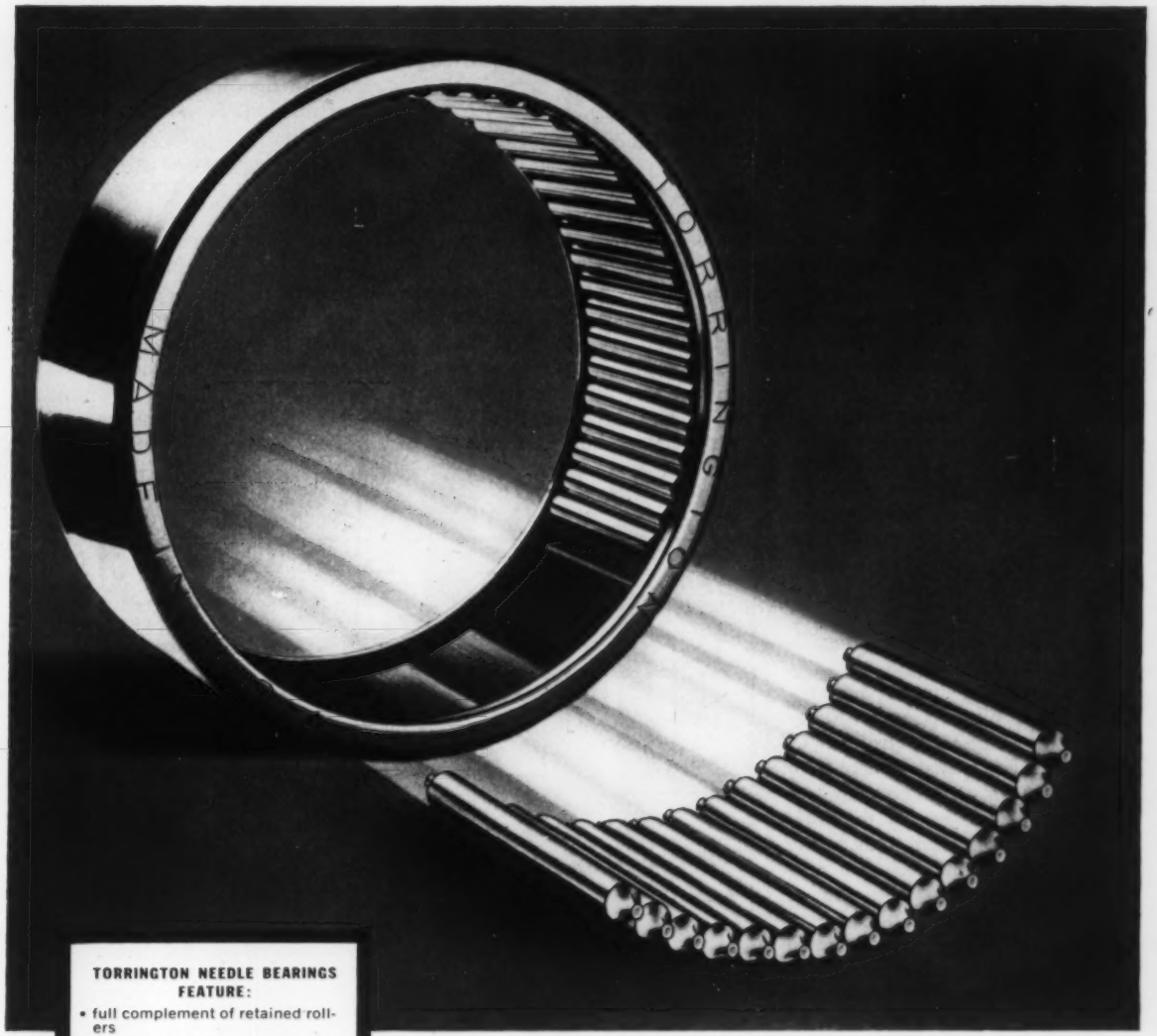
Parts made with refractory tungsten will withstand 5000 F for practical use in reactors and rockets. Potato-shaped object at right is made by brazing together two cups with gold, which has about the same density, to make a radioisotope container which might hold, for instance, the thermal source for SNAP III.





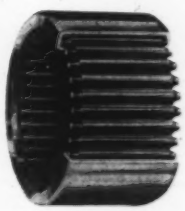
Atom Ship's Turbines Pass Land Tests

First atomic-powered surface vessel for the U.S. merchant fleet—N. S. Savannah—moves a step closer to launching as main propulsion machinery completes shop tests at De Laval Steam Turbine Co., Trenton, N.J. (left). Slated for early installation in the nuclear vessel's hull, propulsion units built by De Laval include main turbines and reduction gearing, turbine generators, main and auxiliary condensers, feedwater heaters and pumps. Flow diagram (right) traces reactor and turbine loops for the 22,000-hp powerplant. Ship will cruise 3½ years without refueling.



TORRINGTON NEEDLE BEARINGS FEATURE:

- full complement of retained rollers
- unequalled radial load capacity
- low coefficient of starting and running friction
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts



Here's Why Torrington Needle Bearings Provide Maximum Radial Load Capacity

The Torrington Needle Bearing's full complement of small diameter rollers provides the largest possible number of bearing contact lines in the load zone.

This feature gives Needle Bearings a higher radial load capacity than any other bearing of comparable size. Precision rollers ensure smooth anti-friction performance with low coefficient of starting and running friction, to match this unequalled capacity. Rollers are positively retained by the turned-in lips of the outer shell, permitting simple, economical installation and assembly.

Torrington experience spans twenty years in design and application of Needle Bearings to equipment of all types. This experience is at your disposal to help you secure the ultimate in performance built into every Torrington Needle Bearing. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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District Offices and Distributors in Principal Cities of United States and Canada

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Russian Engineer Has Access to Half of World's Technical Knowledge

Huge Soviet Information Bureau Is Now Best in Existence, But May Soon Be Challenged by U. S. Document Center

NEW YORK—Soviet engineers probably have access to about half of the world's available technical information through the vast collecting, translating, and disseminating activities of the Institute of Information, says R. K. Honaman, director of publications, Bell Telephone Laboratories Inc. He described the Institute's activities as "the most complete and intensive attack on the problem of disseminating technical information in the world." The Soviet Institute analyzes about 14,000 pieces of technical literature yearly of which about 1500 come from the U.S. Its translation burden has been eased by growing knowledge of English among Russian engineers.

Mr. Honaman made his remarks to the Winter General Meeting of the American Institute of Electrical Engineers where he called for an American system which, instead of merely duplicating the Soviet system, meets the specific needs of the technical professions in America. Referring to President Eisenhower's directive to the National Science Foundation to organize a co-ordinating agency to deal with technical information, he pointed out that no such service now exists. As a result, there is much costly duplication of published information in America and much that goes unpublished.

This situation may soon change, however.

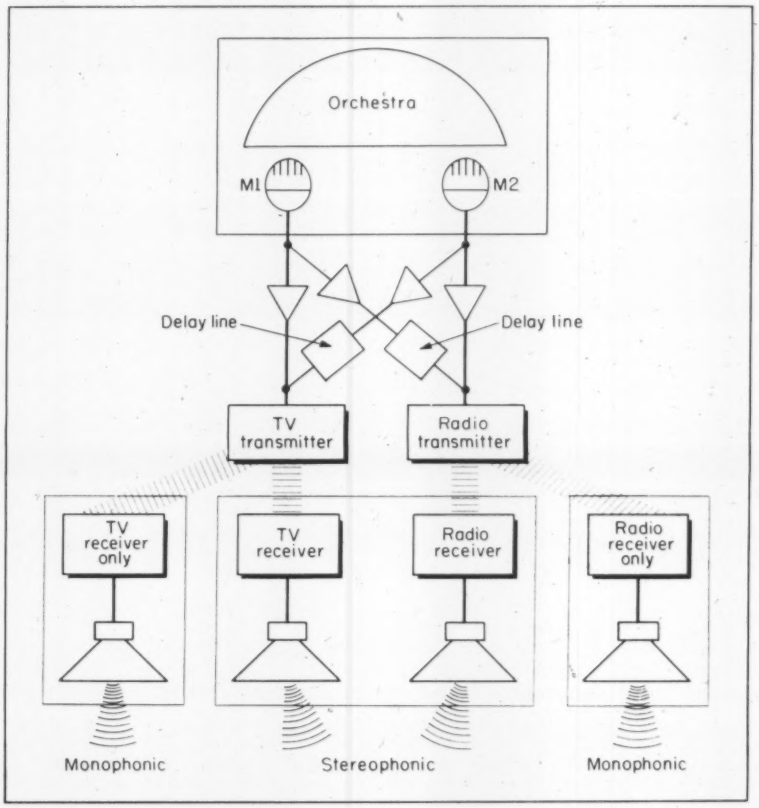
U. S. Document Center

Ohio's Western Reserve University is spearheading a drive to put the U. S. well ahead of Russia in processing technical information. Officials of the school hope to establish a world scientific document center, and can already point to significant progress. They have placed an order with General Electric Co. for an electronic "searching selector"—a machine capable of scanning vast amounts of technical information and coming up with answers to specific inquiries.

James W. Perry, director of the WRU Center for Documentation and Communication Research, gave some idea of the new machine's significance by comparing it to the selector now being used by the University. The old model searches 30 abstracts per hour, while the new one will search 100,000 abstracts per hour. As further indication of its speed, he said the new selector could search the entire 1037 pages of "Gone With The Wind" in 3.5 min, picking out the number of times a word or particular combination of words appeared.

More significant to industry, the machine will be able to search the year's output of the world's metallurgical literature in 6 min or the year's output in chemical literature in 1 hr.

A 3-yr experimental project, conducted by WRU for the American Society for Metals, has proved the feasibility of searching metallurgical literature by machine. Using its present slow machine, WRU is keeping 10 business organizations up-to-date on the most recent science advances in their fields.



Compatible Stereo Sound

Quality reception for both stereo and single-channel listeners is assured with a new broadcasting technique developed by Bell Telephone Laboratories. The technique, which overcomes one of the biggest obstacles to increased stereo broadcasting, is based on a psycho-acoustic phenomenon known as Precedence Effect. It works like this: When a single sound is reproduced through two separate loudspeakers, but is delayed several milliseconds in one, the listener will hear the sound as if it came only from the speaker through which he heard it first. He will judge the second speaker to be silent. The circuit diagram, above, shows PE in use: Microphones are cross-connected to give single-channel listeners balanced reproduction (delay has no effect), and cross connection does not compromise stereo reproduction because of Precedence Effect.

Pinion Tightens Pipe Coupling

Spanner or key-operated pinion makes possible pipe coupling in close quarters where there is not room for a wrench at right angles to the pipe. Seal is not distorted by unbalanced loads, says Stanat Mfg. Co. Inc., Westbury, N.Y., because tightening force operates throughout 360 degrees.

"Light-Foot" Used To Measure Supersonic Sled Performance

LOS ANGELES—Fine degrees of measurement are required to evaluate the dynamic performance of man's fastest earthbound vehicles. Supersonic test sleds like those at Hurricane Mesa and Edwards Air Force Base accelerate from zero to Mach 4 within 30 sec—high-powered performance to be measured in old fashioned units. To more nearly match the speed-time element, electronic engineers at the Edwards Air Base track have initiated a new standard of measurement—the "light-foot."

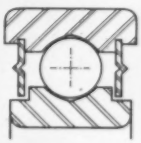
The new term, which denotes the time required for light to travel 1 ft, is proving useful for two reasons: 1. A light-foot is equal to 1.017 times a millimicrosecond, or is the equivalent of a millimicrosecond within 1.7 per cent. For all practical purposes they are equal. 2. Secretaries to development engineers much prefer the term "light-foot" to the tongue-twisting millimicrosecond. A simple abbreviation lf, suffices to record the unit in charts and reports.

EXTRA-THIN BEARING WITH BUILT-IN SHIELDS

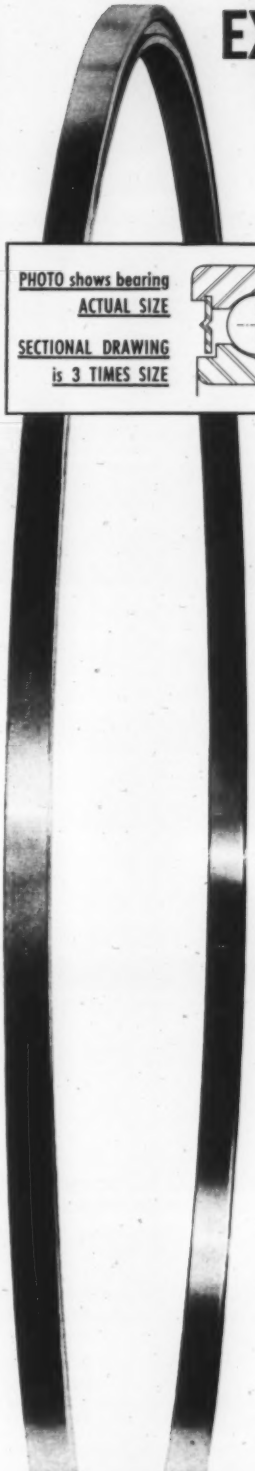
- SAVES SPACE
- SIMPLIFIES ASSEMBLY
- CUTS MAINTENANCE COST

PHOTO shows bearing ACTUAL SIZE

SECTIONAL DRAWING is 3 TIMES SIZE



SIZE: 10.500" OD; 0.270" wide; 0.250" thick.
BALL DIAMETER: 0.125" ±.000025".
MATERIALS: Stainless steel.
MAXIMUM RUNOUT OF OUTER RACE: 0.0002" TIR.
STATIC LOAD CAPACITY: Radial, 4,630 lb.; axial, 13,200 lb.
TORQUE: 5 to 6 inch-ounces at 100 lb. axial load.



Standard bearings often impose limitations on production economy and freedom of design. These restrictions are often eliminated by *special* bearings, custom-engineered by ITI. For example —

To save space, simplify assembly and prevent operating trouble, we designed and are producing this extra-thin-section ball bearing, equipped with a built-in shield on each side in place of separate shields. The shields fit so closely that they retain the lubricant and enable the bearing to pass the standard military sand and dust storm test. This construction assures long-lived low-torque operation, and cuts both assembly and maintenance costs.

YOUR design problem might likewise be simplified or your product improved by ball or roller bearings of special section or configuration, heat resistance, corrosion resistance, ultra precision, or other unusual properties. We design and produce such bearings to individual requirements, in any size from ¼" ID to over 70" OD; and we invite your inquiries.

FREE BULLETIN AFB-2 describes our work in this field—shows a wide variety of "specials"—tells about factors involved in special bearing applications. Write for it!

INDUSTRIAL TECTONICS, Inc.

ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

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WESTERN DIVISION PLANT: COMPTON, CALIFORNIA

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gets to the heart of tough design problems

Light-duty wheels—where a tough, rust-proof, light-weight, easily moldable material is needed—SUPER DYLAN.

Putty knife and paint brush handles—where a low cost, durable material, to which paint will not stick, is called for—SUPER DYLAN.

Auto heater and defroster outlet—where a material must remain dimensionally stable under heat without losing its strength or rigidity—SUPER DYLAN.

Scripto Pen cartridges—where outstanding environmental crack-resistance is a must; clear enough to see the ink supply—SUPER DYLAN.

Roller skates—where a moldable, colorful material with built-in self-lubricating properties to combat friction is called for—SUPER DYLAN.

If you're designing a product that demands a hard-working, chemically-resistant plastic that is strong, easily colored, possesses a glossy finish and is simply processed—SUPER DYLAN is your answer. For more information, write to Koppers Company, Inc., Plastics Division, Dept. MD-39, Pittsburgh 19, Pa.

DYLITE *expandable polystyrene*, DYLENE *polystyrene and* DYLAN *polyethylene are other fine plastics produced by Koppers Company.*

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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MAR. 19, 1959

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405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
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428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
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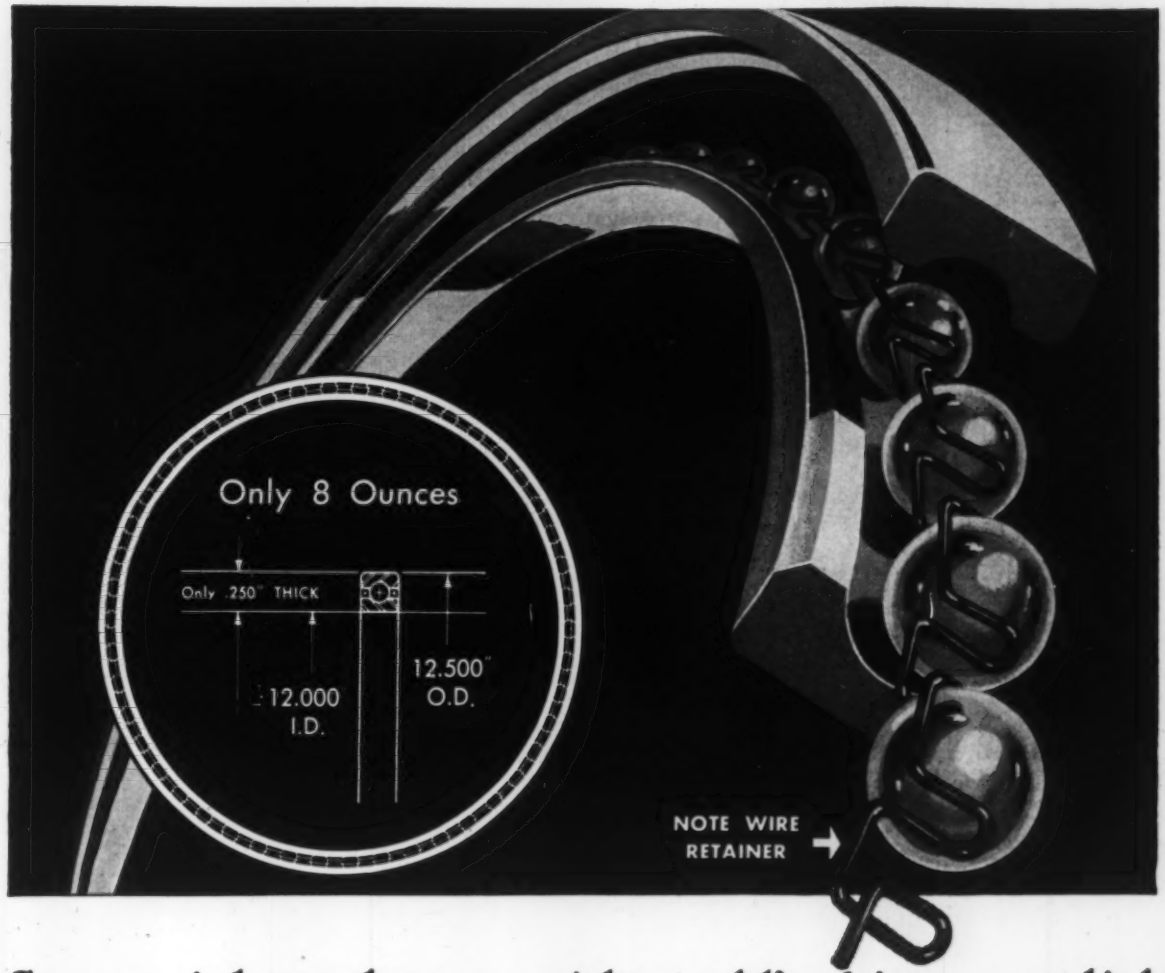


Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

. . . now carried in stock in 4" to 12" bores

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

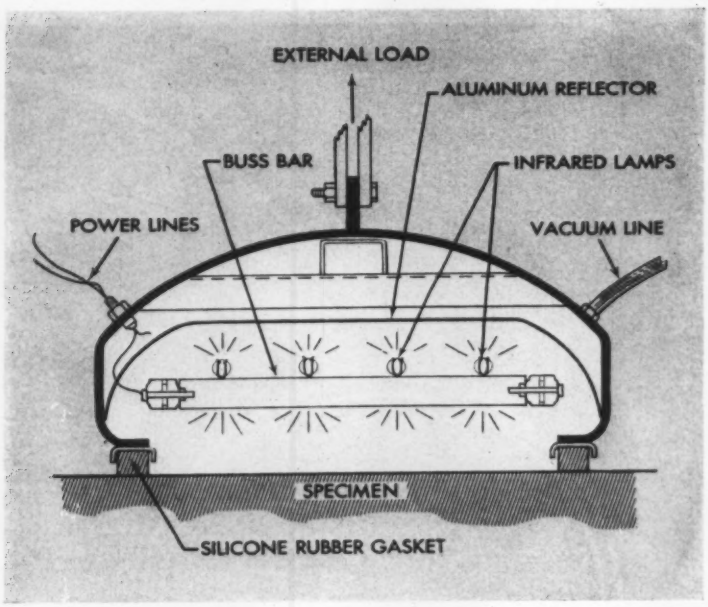
THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561R

All types of ball and roller bearings — 4" bore to 178" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings



Heat lamp and vacuum combine to give stress similar to actual stresses at high speeds.

By J. P. MORAN
Test Engineer
Convair Div.
General Dynamics Corp.
San Diego, Calif.

Hot Vacuum Cells

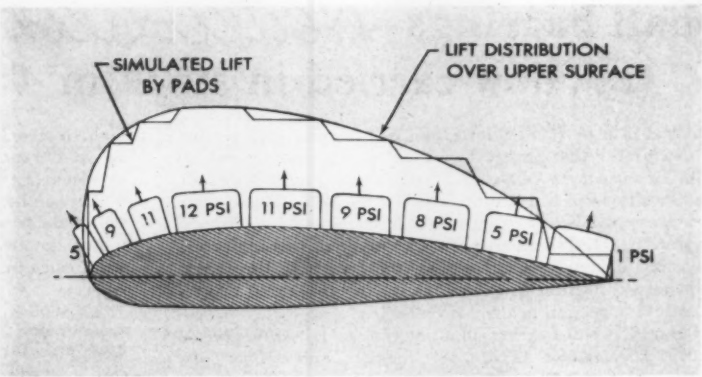
Simulate High-Mach Stresses

At speeds above Mach 2, the stagnation temperature of air rises rapidly, adding a thermal component to air-load stresses on aluminum wing coverings. Here's how Convair simulates the heat and loads of high-speed flight in the structures lab.

A NEW STATIC TEST for aircraft wings takes into account heating effect of high-speed flight. Mach 2 or higher speeds heat airplane wings to above 300 F. Aluminum skin reacts to surface stresses very differently at elevated temperatures. Results are hard to predict, so systems formerly satisfactory for static tests of aircraft wings are no longer sufficient.

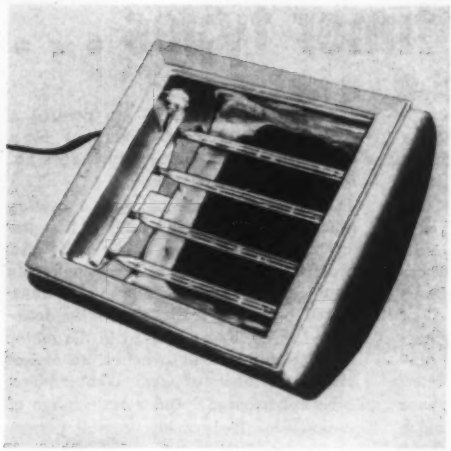
For a more accurate evaluation of thermal effects, Convair's Structural Test Lab has developed a vacuum-heat-tension pad.

Conventional systems employ a rubber pad backed by a steel plate. The rubber is bonded to the specimen surface so that force on the steel plate produces a distributed load. A number of these pads, closely distributed over a wing, give a fair representation of actual flight stresses. Attempts to heat wing sections through such pads have been unsatisfactory due to the low conductivity of the bonding material.

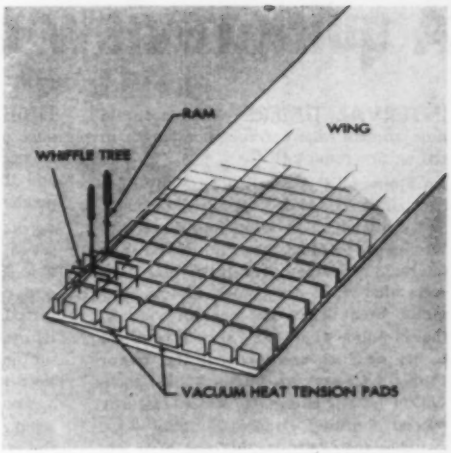


Different-size vacuum pads help approximate wing loading curve. Areas where slope of curve is steep are covered by narrow pads.

Convair's pad is really a vacuum cup sealed with a rubber gasket and enclosing a bank of infrared lamps. It looks like a little barn



Underside of pad shows installation of infrared radiant-heating lamps.



Wing covered with vacuum pads is ready to take stress of dummy "flight." Sharp increase in lift between leading edge and quarter chord is closely followed by narrow pads in that area.

with an arched "roof" welded to two end sections. The roof is equipped with a vertical rod to apply external loads and two pipe fittings—one for vacuum-pump attachments, and one for electric-power leads. Another fitting for internal instrumentation leads may be necessary if strain gages and thermocouples are to be applied inside the barn.

Four lamps in the present model heat specimens from room temperature to 550 F at an average rate of 20 F per second. High-density lamp banks have also been designed which would give a 1500 F per second temperature rise over the same range. The 550 F limit is imposed by the silicone-rubber gasket.

Practical limit for skin loading is 12 psi. At higher vacuums the pad becomes unstable and can be knocked off the specimen by small, eccentric loads.

In use the pads must be loaded carefully to avoid overstressing a portion of the test specimen. Suppose, for example, a 70-lb total load is needed on a pad covering 70 sq in. This would correspond to 1 psi distributed load for that area. Therefore, internal pressure of the pad is pumped down 1 psi below atmospheric pressure, to 13.7 psia. The pad will just stay on when a 70-lb lift is applied, and the total stress on that area is a close approximation of actual flying stress.

But if the cell were pumped down to 10.7 psia, the skin in that area would be grossly overstressed. Even with the proper load applied to the external rod, a true evaluation of the specimen performance is impossible.

Distortion can be avoided with heavy loads if they are applied in steps—first a little vacuum, then external load until the pad is barely holding, and continued alternating increments of vacuum and load in this manner until the desired load is reached.

Cell shapes may be altered to conform to curved surfaces. Width may be varied to adjust area covered. (The area covered by the average pad is 70 sq in., but larger or smaller pads are used to keep step loads of the pads closer to the curve of expected in-flight loading.) Ideal difference in load between adjacent pads is 0.5 psi, but this is often exceeded for practical reasons.

Atom Angles

Civilian use for Krypton 85 . . .
will expand now that AEC has boosted the supply to 100,000 curies per year. Major applications to date have been in self-luminous light sources like aircraft emergency markers, mine safety lamps, and road-sign markers. The reactor-byproduct radioisotope is also used routinely in production-line thickness gages. Cheaper and easier to handle than radium, Krypton 85 causes less deterioration in the phosphor.

Abnormal reactor behavior . . .
will be studied on a small scale in TREAT (Transient Reactor Test Facility), the newest reactor to go critical at AEC's National Reactor Testing Station. Designed to reveal the effects of extreme nuclear heat on fast reactor elements, TREAT will deliver a high-intensity, short-duration surge of nuclear energy to test samples without damage to itself.

States' rights . . .
in the atomic age have been clarified in a study developed by the University of Michigan Law School. Co-directors of the project, William H. Berman and Lee M. Hydeman, say that prompt Congressional action is necessary to avoid overlapping and potentially conflicting state and federal regulation of atomic energy. They recommend that the federal government clearly preempt the field of health and safety control, providing for immediate return of certain specified powers on a state-by-state basis.

Unexpected bargain . . .
in the cost of power generated by the Vallecitos, Calif., reactor has led to predictions that over-all operating and maintenance costs for a proposed unit at Humbolt, Calif., will be substantially the same as for a conventional powerplant. Favorable competitive showing expected for the new plant, according to Pacific Gas and Electric Co. engineers, can be attributed to high fuel-oil costs in the isolated Humbolt area.

A quick review of control timer types . . .

INTERVAL TIMERS — for accurate time control where frequent changes in setting are required.

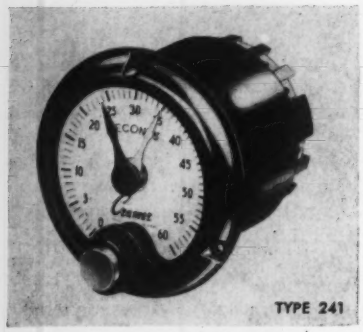
An interval timer consists basically of a constant-speed motor, an arm or cam, and a switch. The user simply sets the mechanism manually to the desired time interval. This action transfers switch contacts that start the timer motor. The motor then drives the arm or cam to the set point, where the switch is returned to its original position and the motor shuts off. A variety of dials, knobs, push-button start, automatic reset features, special housings and additional load switches may be used, but the basic operation is the same in all cases.

TIME DELAY RELAYS — to introduce an accurate and adjustable delay between the closing of a control circuit and the actuation of one or more independent load switches.

Again, a constant-speed motor drives a set of precision-cut cams from an adjustable starting point to a later point where one or more load switches are transferred. The unit continues to the end of its cycle, at which point the motor shuts off and the timer remains "timed out" until it is reset. Optional automatic reset, various clutching devices, and a wide selection of wiring arrangements make the time delay relay a highly versatile control with countless uses.

CYCLING TIMERS — to control a repeated sequence of operations in a definite time relationship which does not require frequent change.

The basic difference between a cycling timer and a time delay relay is that the cycling timer continues to run, cycle after cycle, until it is shut off. The single-pole double-throw load switches are transferred back and forth, at exactly determined times, by cams fixed to the motor shaft. Multiple load switches, an almost endless number of cam combinations, excellent accuracy, and a wide range of basic cycle speeds make the cycling timer an ideal program-control device in many processes.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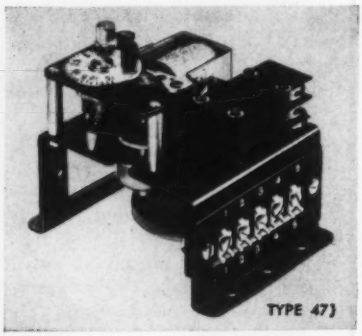
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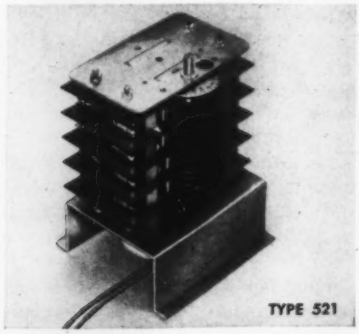

TYPE 521

. . . you can choose at a glance from this table

CLASS	INTERVAL TIMERS		TIME DELAY RELAYS					CYCLING TIMERS	
CRAMER TYPE	241	271	310	330	440A	412	471	511-21	571
Time Ranges	6 s to 24 h	45 s to 24 h	15 s to 120 s	20 s to 80 s	15 s to 3 h	6 s to 24 h	15 s to 24 h	6 s to 48 h	60 s to 3 h
Load Switches (SPDT)	1	1 or 2	1	1 or 2	1 to 5	1	1 or 2	1 to 8	1 to 4
Automatic Reset	Yes	No	Yes	Yes	Yes	Yes	Yes	—	—
Repeat Accuracy (% of total range)	¼%	½%*	½%	¾%	½%	¼%	2%	½%	1½%
Progress Indication	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Adjustable	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Operated by:									
Momentary contact	No	No	No	No	Yes	Yes	Yes	No	No
Sustained contact	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mounting	Panel	Back Panel	Panel	Surface	Surface	Panel	Surface	Surface	Surface
Unit List Price	$24.00	$ 8.00 or $10.00	$27.00	$18.00 or $23.00	$42.00 to $66.00	$42.00	$23.50 or $27.50	$16.00 to $44.00	$ 8.50 to $11.50
Motor & clutch rating	All standard voltages in 50, 60 and 400 cps AC, and in DC								

**Exclusive of human setting error*

LEARN MORE about these and other basic timing devices from Cramer's complete line. Write for free bulletins on the types that interest you — or describe your problem and let us help you solve it.

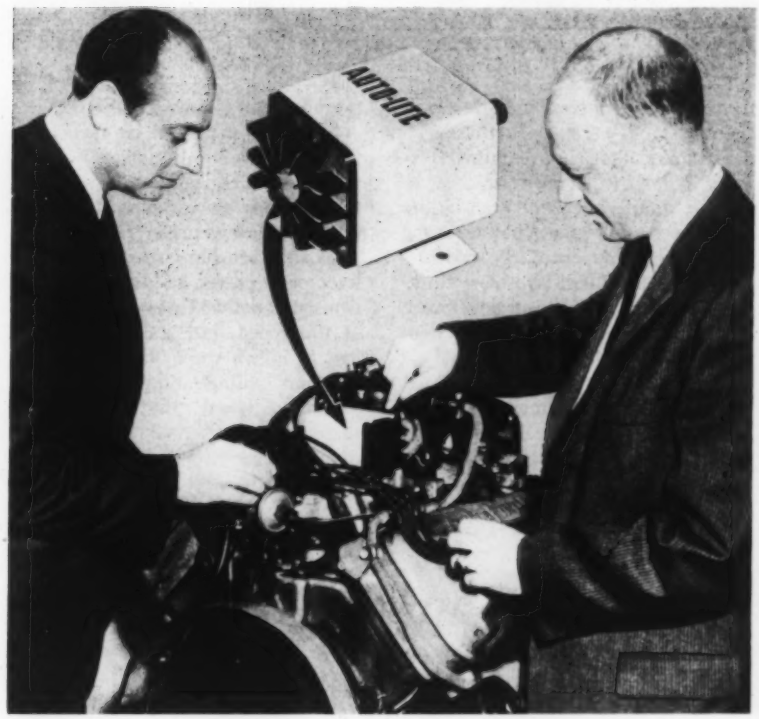
CRAMER CONTROLS
CORPORATION
Box 6, Centerbrook, Connecticut

Circle 414 on Page 19

Transistors Give New Jolt To High-Power Auto Engines

High-compression auto engines have taxed present ignition systems to the limit. But a new transistorized ignition system may break this bottleneck by offering these advantages over conventional systems:

- **Increased output voltage**
- **Longer life for contacts**
- **Better high-speed efficiency**
- **Constant voltage output**
- **No deterioration with age**

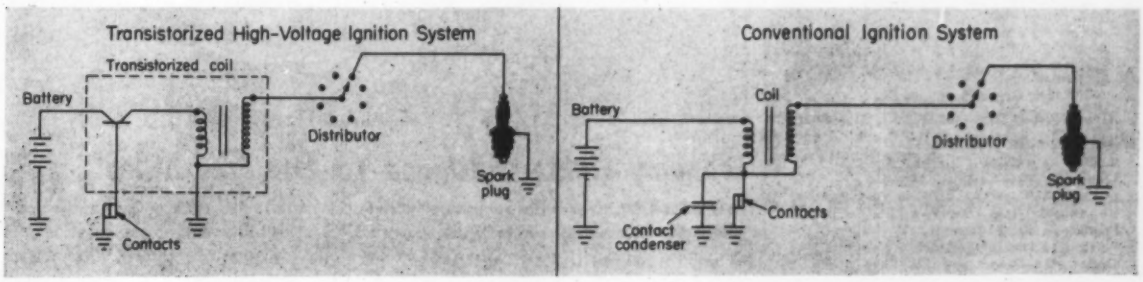


Transistor-switched transformer is mounted in place of the engine coil and requires about the same precautions. Ambient temperatures should not exceed 180 F. Mounted on an industrial engine, transistorized package gives full electric output at high speed and longer running time without maintenance.

IN 1961, you may be able to buy a car with transistors in the ignition system. Electric Auto-Lite Co., Toledo, Ohio, predicts that their new system will be available as optional equipment for about the price of power steering.

A transistor will switch the heavy primary current now carried by distributor contacts. It will be controlled by a much lighter current regulated by the contacts. A new type of transformer matched to the transistor's characteristics is also included. The two items are contained in a package slightly larger than the conventional car coil and designed to replace it. (See prototype system, MD, Dec. 11, 1958, p. 12.)

Need for such a system comes



Contacts in the new system operate on low voltage to trigger a transistor switch, which controls primary-circuit current. Condenser is eliminated and protection for the transistor from back emf is built into the system. In conventional system, right, a set of contacts switches primary current directly; spark voltage drops at high speed.

From raw material to finished product, she's the boss . . . on top of the job and directing every turn.

For the same reasons, nobody can provide as complete application and fabrication engineering service on PRECISION BERYLLIUM COPPER STRIP as the company who controls its quality in each step of manufacturing from raw ore to packaging of finished strip.

Whether your problem requires design assistance, development of manufacturing techniques, special heat treatment or any other processing information, call your nearest Pennrold Service Center for an experienced field engineer.

The Brush Beryllium Co. and its Pennrold Division offer you the world's most completely integrated facilities for the production of the finest precision beryllium copper strip rolled today. With it, you get complete application engineering service, the widest range of sizes (down to 0.0005" thick) and the largest coil size in the industry (for greater uniformity and faster delivery).

Complete application and fabrication engineering service is also available to users of precision rolled phosphor bronze and other special purpose alloy strip.

For more information, quotations, or fast delivery—call your nearest Pennrold Service Center, today!

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St. Louis, Mo.— SHerwood 1-6423
Greensboro, N. C.— BRoadway 3-5973
Los Angeles, Calif.— PLeasant 3-5531

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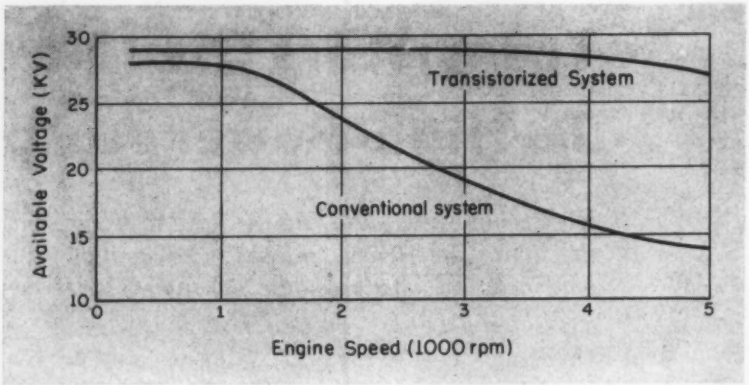
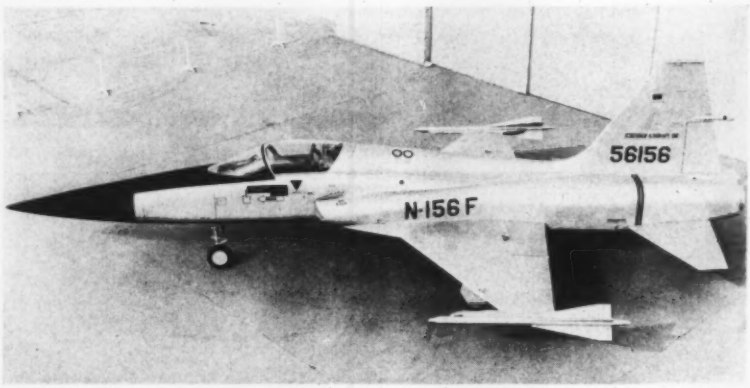


Constant output of transistorized system is contrasted to sharp drop in output of conventional system as engine speed increases. Voltage drop in the old system results when contact periods become too brief for full energy build-up

from high compression ratios and speeds of today's auto engines. To meet spark ignition demands, primary voltage has been boosted to 12 v; double-breaker distributors have been designed; ballast type temperature-compensating resistors have been installed; improved tungsten contacts have been developed. Still the present car ignition system is taxed to the limit and often fails in cold weather or with prolonged use. The greater demands of even higher compression, and more speed would seriously reduce the life and performance of present systems.

Because fast-moving contacts often fail to deliver full power between make and break, operators of tractors, marine power plants, and industrial engines prefer magneto systems that are hard starting but deliver peak power at full speed. The transistor delivers nearly full power at top speed, but suffers no power loss at idling speed, thus offering a constant voltage output from low to high speed that cannot be matched by present battery or magneto systems.



Economy Fighter Designed To Arm Free Allies

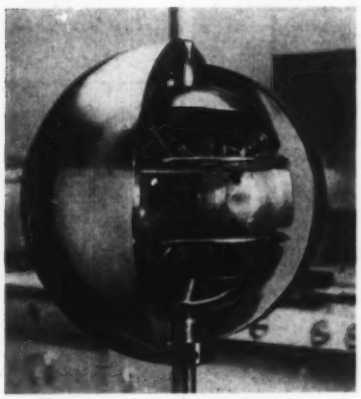
Low-priced fighters with combat effectiveness superior to that of presently operating Century series aircraft are planned to stretch the taxpayer's dollar and help arm our free allies. Low cost of development, together with ease of manufacture and simplicity of airfield requirements, accounts for savings to purchasers and users. The U. S. Air Force is investigating a development contract for the supersonic fighter, designated the N-156F, with Northrop Corp., which has been carrying this project in parallel with the Air Force T-38 project.

Hi-Fi Recording Theories Challenged as Obsolete

NEW YORK—Recent studies indicate that some of the basic audio-engineering theories now in use are obsolete, according to John G. McKnight, vice president advanced audio section, Ampex Corp. He challenged the generally accepted principle that most of the power in music is concentrated within only a few octaves in the middle register.

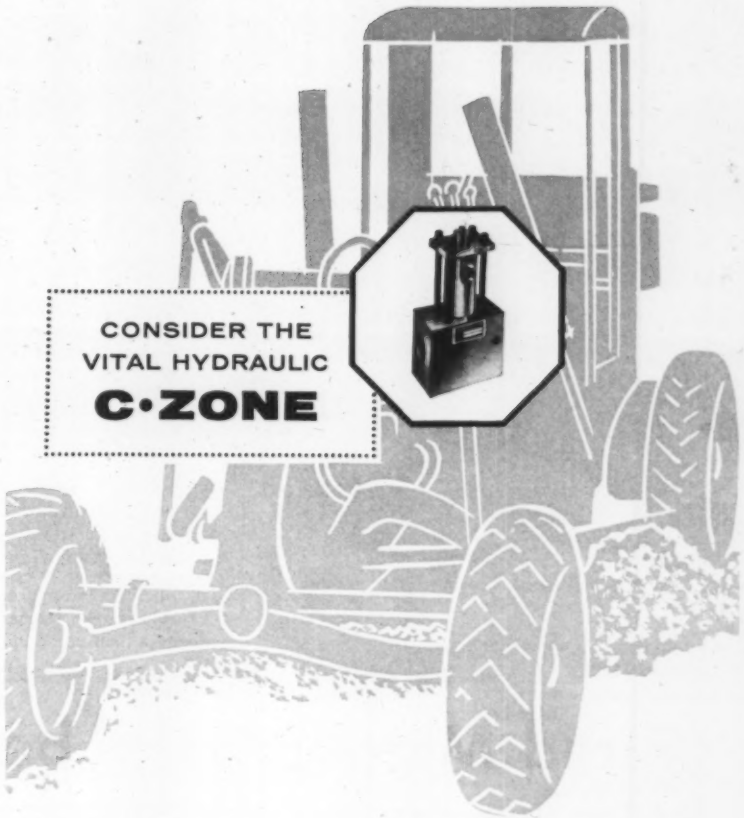
According to McKnight, the peak energies at the upper and lower extremes of the audible range are almost as great as those in the mid-range. While earlier theories have justified the design of sound and recording equipment which is incapable of handling as much power in the high and low registers, future equipment must have not only a "flat" frequency response, but also a power range which is essentially linear in the audible range.

Magnetic tape offers the best means of true hi-fi recording, according to McKnight.



Ball Built to Bake Bread

This prototype spherical oven was recently unveiled by Alcoa to demonstrate the possibilities of aluminum in homeware design. The shape of the future in cooking may be the sphere; the material for the future in cooking will be aluminum, says designer Greta Grossman. Alcoa engineers say the shape is as efficient as the conventional rectangular form, and evaluation tests may prove it more so. The oven can be adapted to future sources of energy like solar energy, induction heating, and ultrasonics.



MORE USABLE HYDRAULIC POWER WHEN THE CONTROL ZONE IS WATERMAN

Waterman Valves and Accessories for Hydraulic Systems

Flow Regulators

Solenoid Valves

Filters

Check Valves

Pilot Checks

When you specify components for hydraulic systems—either mobile or stationary—give a second thought to the vital elements of the *Control Zone*. When you write in *Waterman* for DC or AC solenoid valves (like the ¾" No. 314 shown above), you specify many extra values that no other valves can give: Pilot operation, for wider valve opening, lower pressure drop, less power consumption; operating pressures up to 3000 p.s.i. with high-strength aluminum alloy bodies; easier installation; complete accessibility of all working parts; continuous-duty solenoids with modern plug-in connectors; fast, positive valve action. Every Waterman valve is factory-tested before shipment. And yet all this extra value costs you no more. Specify Waterman—and be *right . . . from the start.*

W-5910

Waterman representatives are in all principal cities. Write for Waterman Solenoid Valve Catalog No. 2000, and for Waterman Flow Regulator Catalog No. 1000. Also suppliers of AN and MS qualified flow regulators and fuses.

Waterman Engineering Company, 725 Custer Ave., Evanston, Illinois

WATERMAN ENGINEERING COMPANY

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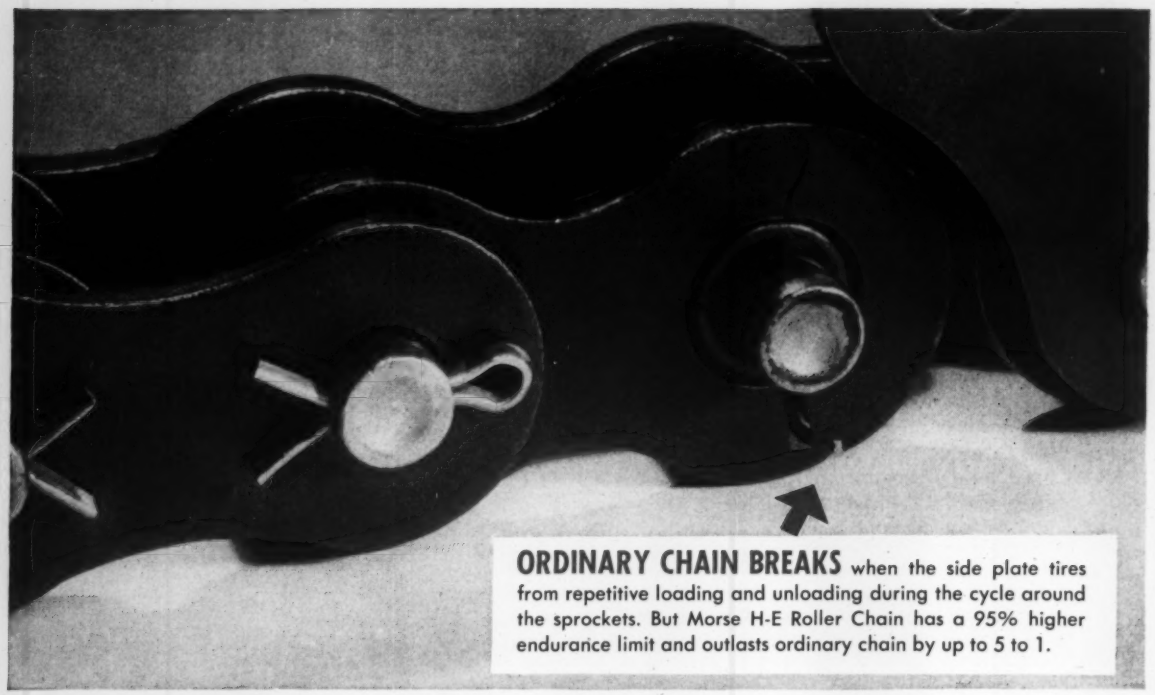


ORDINARY CHAIN BREAKS when the side plate tires from repetitive loading and unloading during the cycle around the sprockets. But Morse H-E Roller Chain has a 95% higher endurance limit and outlasts ordinary chain by up to 5 to 1.

"Tired Metal"... the bane of chain now licked by MORSE H-E

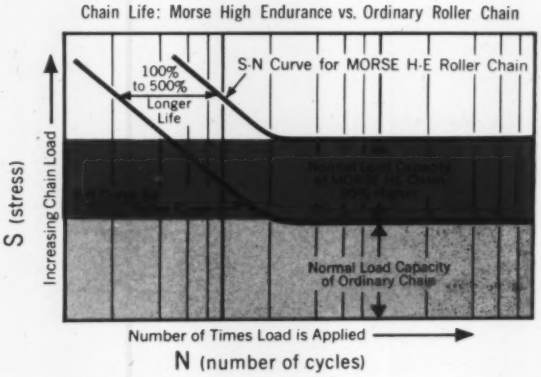
Morse H-E Roller Chain has up to 500% longer service life . . . cuts replacement and labor costs

The unretouched photograph shows what happens to chain when the metal fatigues. But now a special Morse process has licked the "tired metal" problem. It gives Morse H-E Roller Chain 95% higher endurance limit . . . and up to 500% longer service life.

The special process means Morse H-E Chain costs about 10% more. But that's a small price to pay for a heavy-duty chain that can save you thousands of dollars annually in replacement costs, downtime, and wasted man-hours.

For more information on the chain that licked the "tired metal" problem once and for all, see your local Morse Distributor. Or write: MORSE CHAIN COMPANY, Dept. 6-39, Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Illinois.

Chain Life: Morse High Endurance vs. Ordinary Roller Chain


100% to 500% Longer Life
S-N Curve for MORSE H-E Roller Chain
Normal Load Capacity of Ordinary Chain
S (stress)
Increasing Chain Load
Number of Times Load is Applied
N (number of cycles)

Red area: Under these chain loads, fatigue will break ordinary chain . . . but *not* Morse H-E.

White area: Under these loads, fatigue will break ordinary chain and Morse H-E . . . but Morse H-E will have operated 100% to 500% longer.

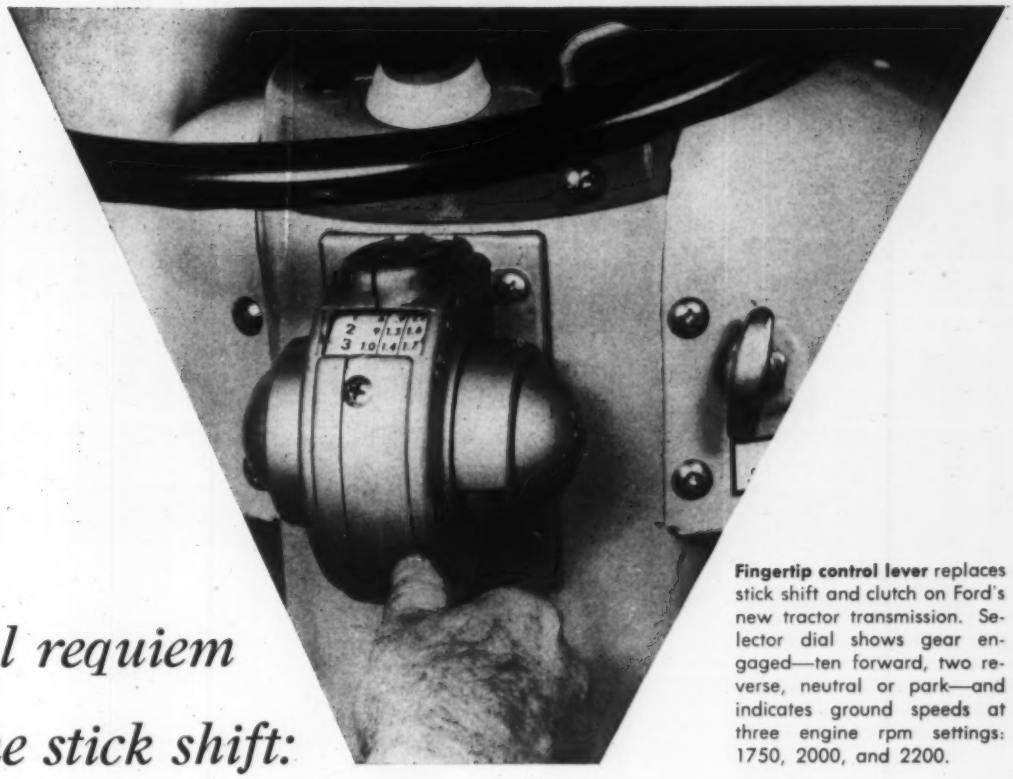
MORSE *Trademark

MORSE B-W BORG-WARNER

A BORG-WARNER INDUSTRY

REMEMBER: Only Morse offers you all four of these basic drives: Roller Chain, Silent Chain, Hy-Vo®, and "Timing"® Belts.

Circle 417 on Page 19



Fingertip control lever replaces stick shift and clutch on Ford's new tractor transmission. Selector dial shows gear engaged—ten forward, two reverse, neutral or park—and indicates ground speeds at three engine rpm settings: 1750, 2000, and 2200.

Rural requiem for the stick shift:

Tractors Go Semiautomatic

ONE BIG DIFFERENCE between Ford's semiautomatic tractor transmission and the hands-off shift in the farmer's new car is efficiency. With a little help from the operator, the semiautomatic keeps the tractor engine running at its most efficient speed at all times.

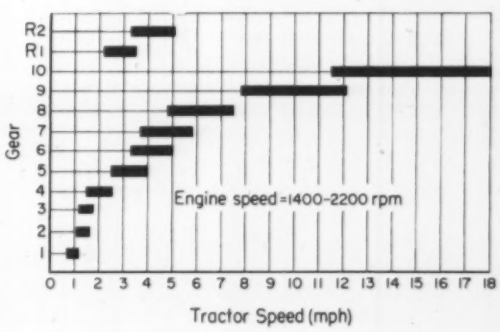
This was a design requirement. Constantly changing load demands —hilly terrain, variable soil, thick and thin hay baling—keep most transmissions and operators from using full efficiency of the engine. The conventional transmission requires too much clutching, has too few gear ratios, or both.

An automatic transmission is equally inconvenient, according to Ford. On many jobs it works on a borderline between two ratios and tends to hunt. Also, with automatics and, to a lesser extent, with torque converters, the tractor increases speed rapidly when the load is removed (at the end of a furrow).

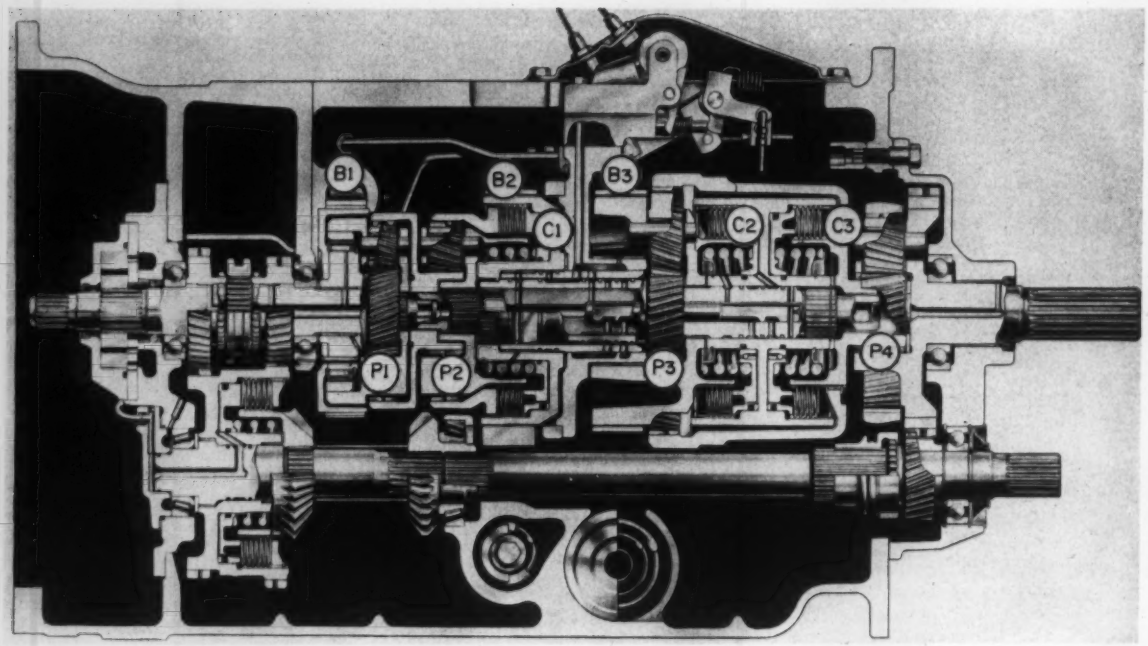
With the farm Fordomatic (it's called Select-O-Speed), the operator can quickly and easily up-shift or down-shift through ten forward speeds without stopping the tractor. He keeps ground speed and power output under his control at all times. Forward speeds range from 0.6 to 18 mph at engine speeds of 1200 to 2200 rpm.

A feathering, or inching, pedal in place of the clutch pedal permits moving the tractor slowly for hooking up implements, starting heavy loads, or for stopping the tractor without gear-ratio change.

The independent power takeoff, operated by a separate push-pull handle, can be engaged or disengaged with the tractor in motion. Two standard PTO speeds are provided: 540 and 1000 rpm. A ground-drive PTO, which interprets forward movement of the tractor wheels in-



An optimum speed for every job was a design objective in the new transmission. Steps in ratio change are kept as even as possible, within limitations of the planetary gear train.



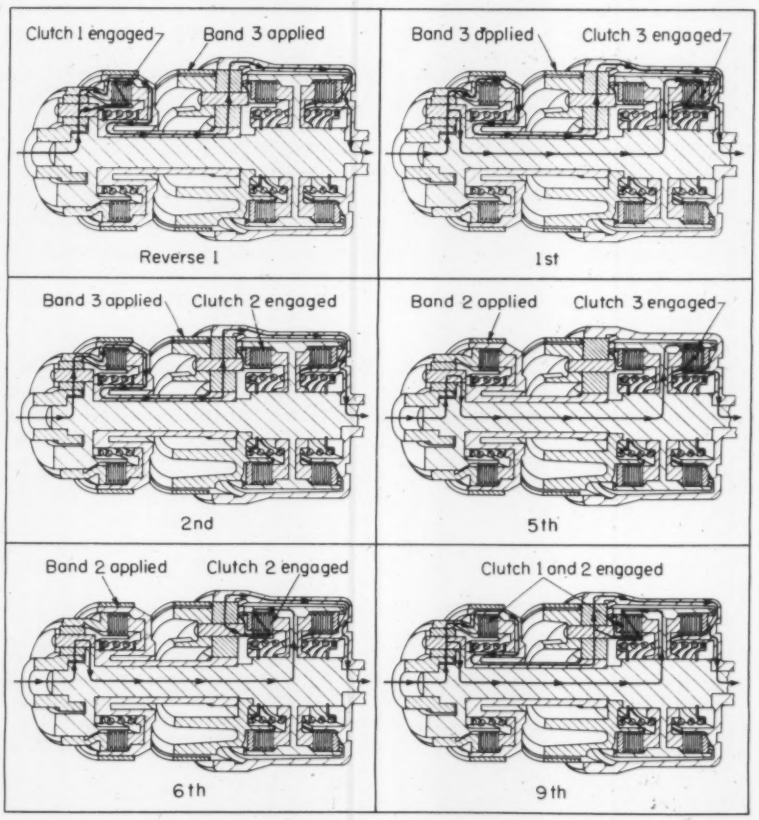
to PTO revolutions, is also available.

All transmission clutches and brakes are actuated by hydraulic pressure. Each unit is controlled by a cam-actuated spool in the valve body. The cams have a position for each of the ten forward speeds, two reverse speeds, neutral, and park. Brakes and clutches are pressure-actuated except brakes 2 and 3 (see cross section), which are spring-loaded and released by applying hydraulic pressure. This gives the park position on the selector and automatically locks up the transmission when the engine is stopped and hydraulic pressure is lost.

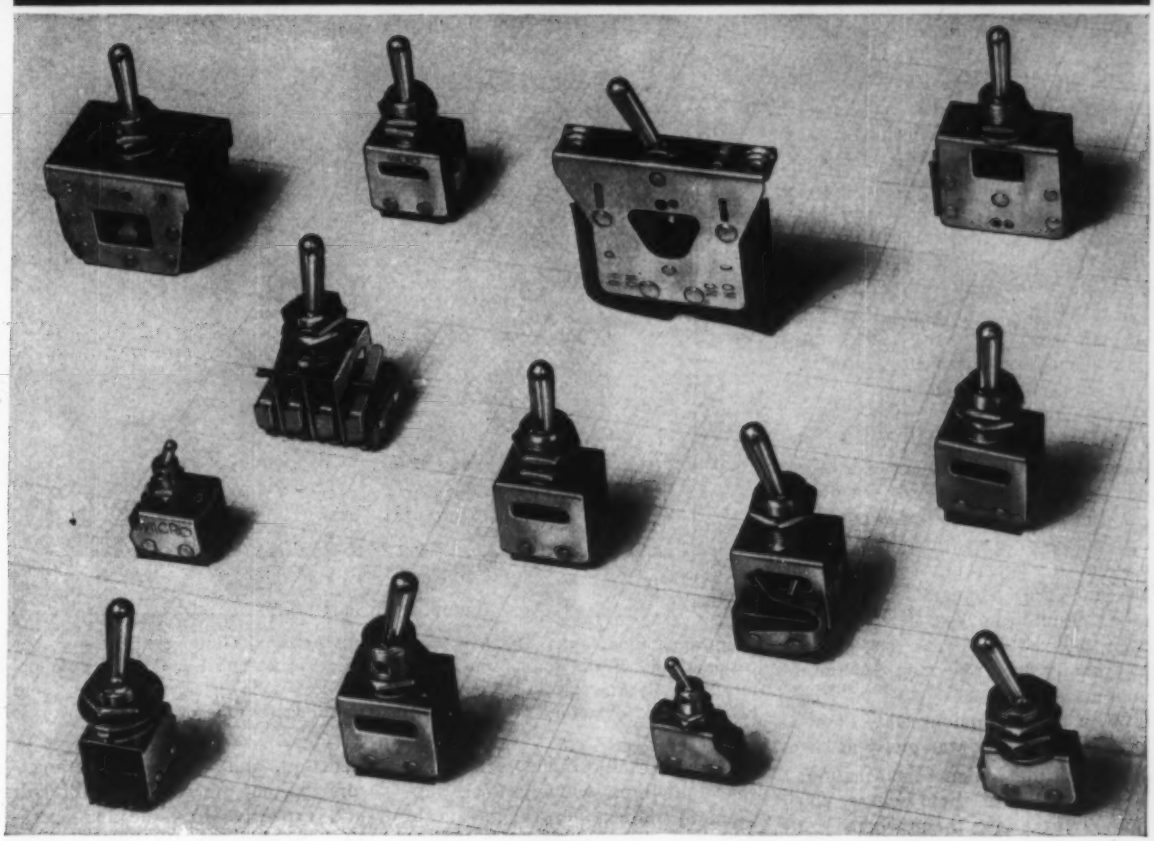
Ford designed Select-O-Speed to fit in the same size package as its standard tractor transmission. Mounting flanges are also identical, giving complete interchangeability.

Care was also exercised to produce a balanced design. With very high reduction ratios in the low gears, it is not practical to design for full engine torque through the transmission because traction would always be a limiting factor. Therefore, two design parameters were established, one for maximum drawbar pull and one for maximum engine-input torque. In the higher gears, the engine torque is the limiting design factor for strength and capacity. In the lower gears, drawbar pull is the design factor.

Power shifting is accomplished by three hydraulic clutches, C, and three brakes, B, controlling four simple planetary gear sets, P. The first planetary set gives overdrive or direct, the middle two sets are controlled to give five forward and one reverse speed, and the fourth set is constant reduction. Power flow in the five basic forward speeds and reverse is shown below.



MICRO SWITCH Precision Switches



Compact "AT" toggle switch assemblies meet wide range of requirements in small space

The 13 toggle switch assemblies illustrated above represent a group of more than 100 similar compact assemblies designed to actuate from one to as many as a dozen miniature precision basic switching units. They find wide use in aircraft, mobile, marine, electronic, and all panel applications.

In this group are 2- and 3-position switches, in all combinations of contact arrangements . . . with either maintained or momentary lever positions. Within the group are switches for special requirements. For example, the switch at upper right includes an "electric memory" unit that indicates by a light or buzzer which circuit was last actuated. Other assemblies in the line feature pull-to-unlock levers, sealed levers, and hermetically-sealed basic switches.

All are manufactured with utmost precision, with consideration given to such important details as rigidity, positive "feel" and positive action, ease of mounting, good appearance, and long life.

"AT" toggle switch assemblies are described fully in Catalog 73. Assistance in switch application is available from the MICRO SWITCH Branch Office near you.

MICRO SWITCH . . . FREEPORT, ILLINOIS
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Honeywell
MICRO SWITCH PRECISION SWITCHES

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Don't Count the Vacuum Tube Out!

Tube Makers Deny Transistor Will Take Over on All Fronts

TECHNICAL MATURITY — with no apparent overtones of senility—seems to sum up the informed consensus on the state of the electron tube in 1959, the year which marks the Tenth Anniversary of the invention of the transistor. Although the victory of the transistor is complete in some areas—it suffers no real competition in computers, for example—the vacuum tube has shown surprising tenacity in many other electronic applications.

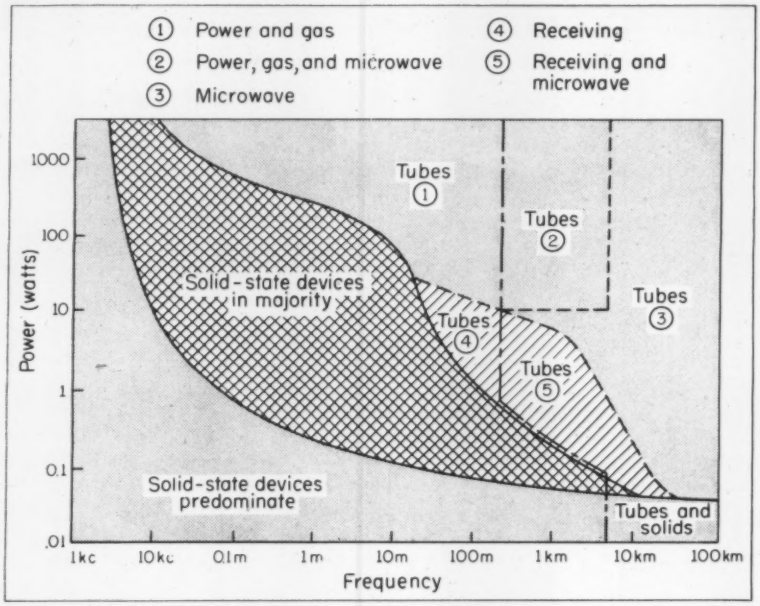
Production figures for the past year make the point: Total transistor production boomed to a 45-million level during 1958; yet during the same year, 450 million electron tubes were manufactured. Obviously, designers are still finding use for the 53-year-old vacuum tube, despite the fact that it has been called the "weak sister" in just about every electronic-component assembly.

Why this anomalous state of affairs? One answer was given at the AIEE Winter General Meeting: *Transistors?* Use them where you can. *Tubes?* Use them where you must.

Such a rule-of-thumb leaves little room for doubt that transistors will take over many of the areas previously served by tubes. However, as General Electric's Robert Moe (Manager - Engineering, Receiving Tube Dept.) pointed out: ". . . there are grey areas where either tubes or transistors will serve equally well. . . . and many, many fields where tubes are and will continue to be superior. The advantages and disadvantages of each device, under the wide variety of operating conditions and circuit requirements, should govern the choice for a particular application."

Rounding up the "pros and cons" on factors which guide a designer's choice, Mr. Moe presented this comparison on tubes versus transistors to the AIEE audience:

Power Requirements: If available power input is limited, and high power output is not a prime requirement, transistors are the logical choice. For example, in hearing aids, personal portable radios, or even in space satellites, which are all supplied by battery power, low drain and high efficiency are prime factors. On the other hand, if the equipment is ac-operated, these are of little consequence, and other factors will govern which may well favor tubes over transistors.

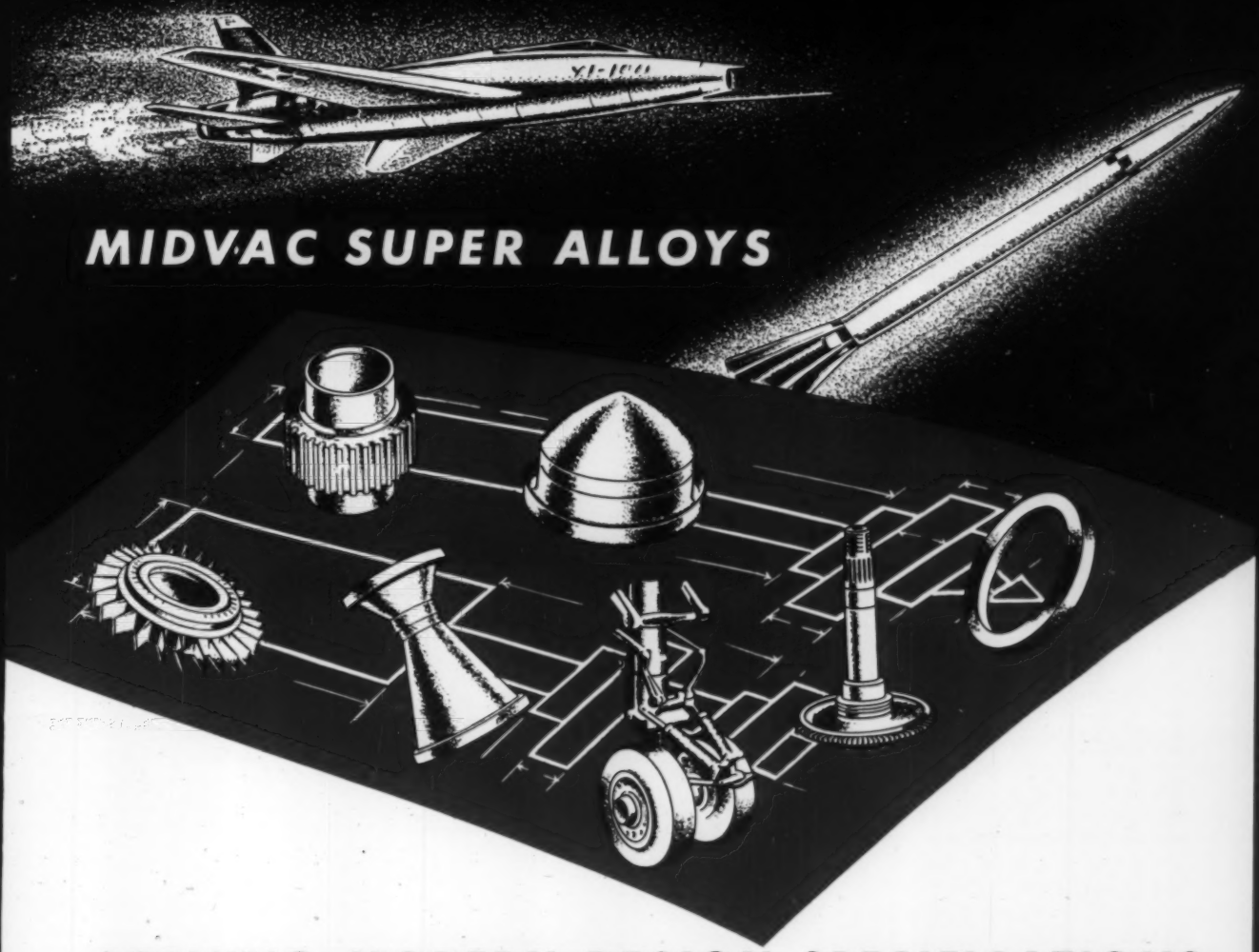


Long-range planning of Defense Department's Advisory Group on Electron Tubes assumes this distribution of the frequency-power spectrum between semiconductors and electron tubes. Breakthrough in either tube or transistor arts could be expected to modify positions of the semiconductor-tube dividing lines.

Ambient Temperature: Semiconductors are far more sensitive to changes in temperature than tubes. Germanium and, to a lesser extent, silicon units show considerable variation in parameters with temperature change, reaching a limiting capability around 100 C and 200 C, respectively. Tubes, on the other hand, can operate well above 200 C bulb temperature in the glass types, and over 400 C in ceramic with practically no change in characteristics. Thus, use of transistors under varying ambient conditions requires a great deal of attention to temperature-compensation elements and feedback circuits, where, in most cases, such precautions are unnecessary with tubes.

Frequency: At the present time, and with presently available construction and techniques, transistors become increasingly difficult and expensive to build for operation above 500 kc. Refinements, of course, are being introduced, but there is a fundamental conflict between barrier thickness, area, and carrier mobility, versus capacitance, gain, and power-handling ability (heat dissipation) with increasing frequency. Tubes, of course, have these problems to some extent because of transit-time effects and interelectrode capacitance loading. However, even the most optimistic predictions by transistor manufacturers provide little hope that they will take over present VHF and UHF tube applications (from 100 to 1000 mc) in the foreseeable future.

Noise: Although relatively free of microphonics and variable leakage path noise contributions, transistors have an inherently higher random noise output than tubes, when considered on a noise power basis. Thus transistors may well be chosen for low-level stages of audio preamplifiers to eliminate microphonics and hum. They would be unsuitable,



MIDVAC SUPER ALLOYS

SOLVING MODERN DESIGN SPECIFICATIONS

Parts for Missiles—Rockets—Jet Engines are constantly calling for newer alloys to operate at higher temperatures. Alloys made by the Midvac process of consumable electrode melting are currently answering these needs and new ones are being developed in anticipation of more critical operations.

Midvac Alloys insure increased tensile and impact properties, improved stress rupture strength at elevated temperature, and longer fatigue life.

Standard commercial alloys can also be made with increased cleanliness resulting in higher properties than have been available under conventional means.

Offered in ingots, billets or forgings for the production of missile combustion chambers, tail cone assemblies, jet engine parts, aircraft landing gear components or any other parts requiring properties beyond the capabilities of conventional steels.

MidVac Steels

MIDVALE-HEPPENSTALL CO., NICETOWN, PHILADELPHIA 40, PA.

Subsidiary of HEPPENSTALL COMPANY, Pittsburgh, Pa.

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however, for wide-band IF or RF amplifiers in radar or television where a noise figure approaching the theoretical minimum is a prime requirement.

High Voltage: Because of the inherently better insulation afforded by vacuum devices, it is expected that tubes for high-voltage devices, both diodes and multielement, will be simpler, more economical, and more reliable than semiconductors for some time to come.

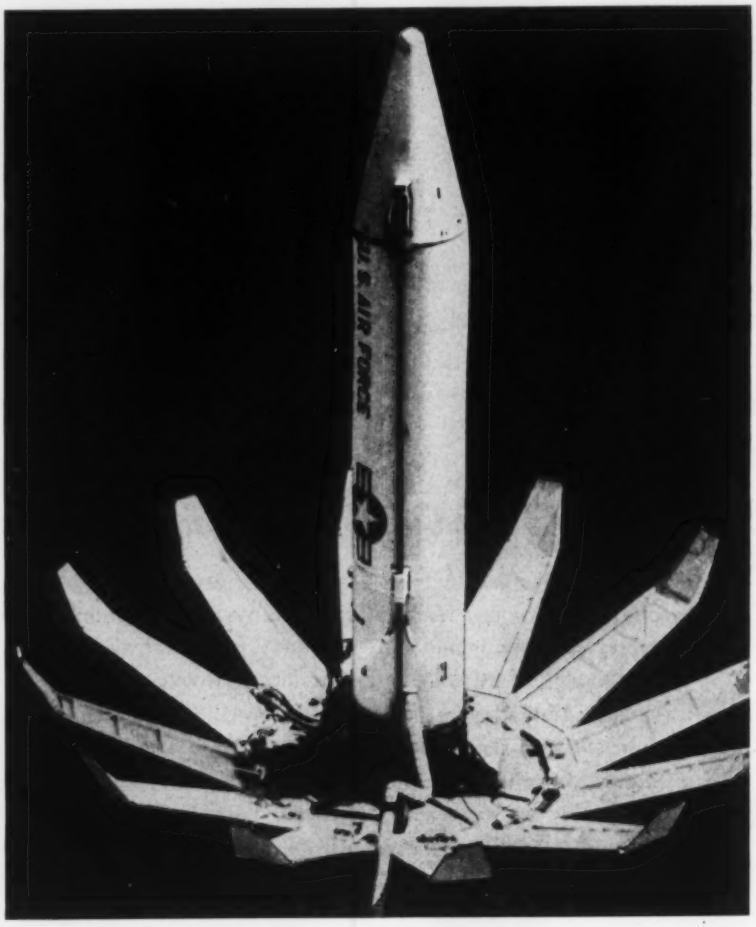
High Power: Because of the elaborate measures necessary to cool the junction of a power transistor, and the relatively expensive components necessary to filter and regulate a low-voltage, high-current supply, vacuum-tube power amplifiers will probably continue to have an economic advantage for some time to come.

Spread and Control of Characteristics: At the present time, the properties of semiconductors are more difficult to control in production than those of tubes. In most cases, the spread of characteristics is too wide for any one intended application, requiring the selection and labeling of several different portions of the over-all product into various groupings for gain, breakdown voltage, etc. Some of this variation will undoubtedly be reduced by further manufacturing refinements, but some of it may be inherent in the nature of the device. Therefore, where spread of characteristics, or close tolerances, or the ability to turn out uniform products over an extended period is a prime consideration, tubes should continue to be superior.

Nuclear Radiation: Available unclassified data show transistors to be definitely vulnerable to high-energy gamma radiation. Tubes are not affected to any measurable degree. For thermal and fast neutrons, the various reports indicate that, for equal dosage, glass tubes will last 100 times as long, and ceramic tubes about 1000 times as long as transistors.

Reliability: In terms of survival under equivalent operating conditions, there is practically no information comparing tubes and transistors directly. As a practical matter, voluminous specifications, both manufacturers' and military, are available which guarantee a "floor" under allowable failure rates of tubes and a very good probability that most lots will give better than 99 per cent survival at 1000 hr under maximum rated conditions. Such survival specifications are completely lacking for transistors. This is not to say that transistors do not have a very high potential reliability, possibly somewhat better than tubes, but that prediction, control, and statistical evidence of consistent survival under comparable environmental conditions are not yet available.

Physical Size and Weight: While transistors obviously have the advantage over tubes on both of these counts (except for ceramic tubes), the unit itself is not the whole story. In the case of power transistors, the heat sink and radiator must be many times the size of the transistor and may well be larger than a tube of the same output rating. Similarly, in large installations involving many thousand units, the air conditioning may have to be just as large for transistors, in spite of their low power consumption, since the allowable rise cannot be as great.



Missile Cozy

A sectional seal of aluminum panels keeps the weather away from vital instruments and equipment in space-waiting Jupiter IRBM's. The 30-ft panels, controlled by synchronous motors, are raised when preflight adjustments are complete, spread open prior to blast-off. Doors and ports in several of the panels permit entrance for inspection and fuel-line connection. Interior of the shelter is coated with a paint that withstands 1000-F temperatures. It was designed by Army Engineer Research and Development Laboratories, Ft. Belvoir, Va.

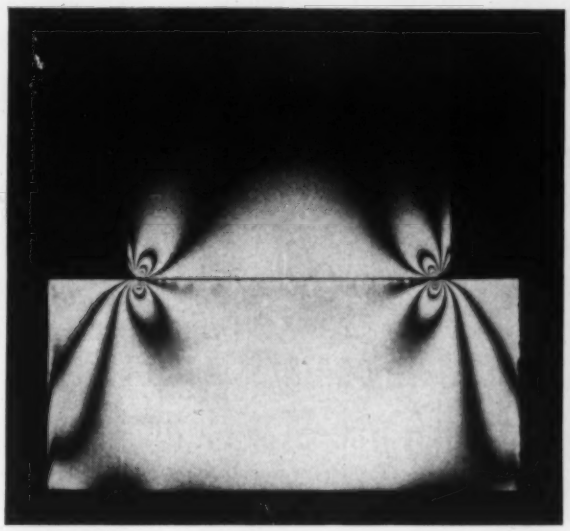
TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

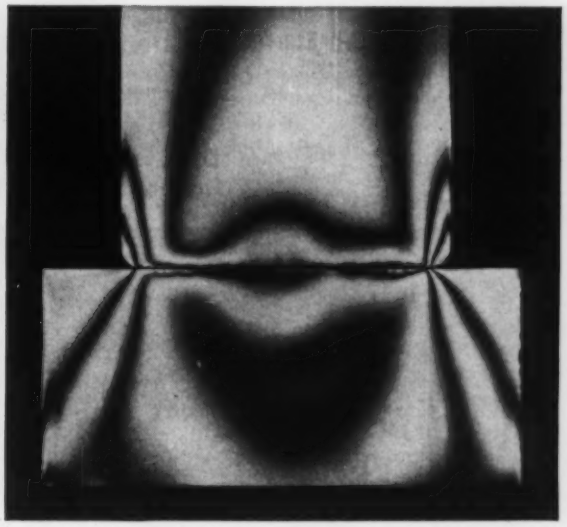
TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

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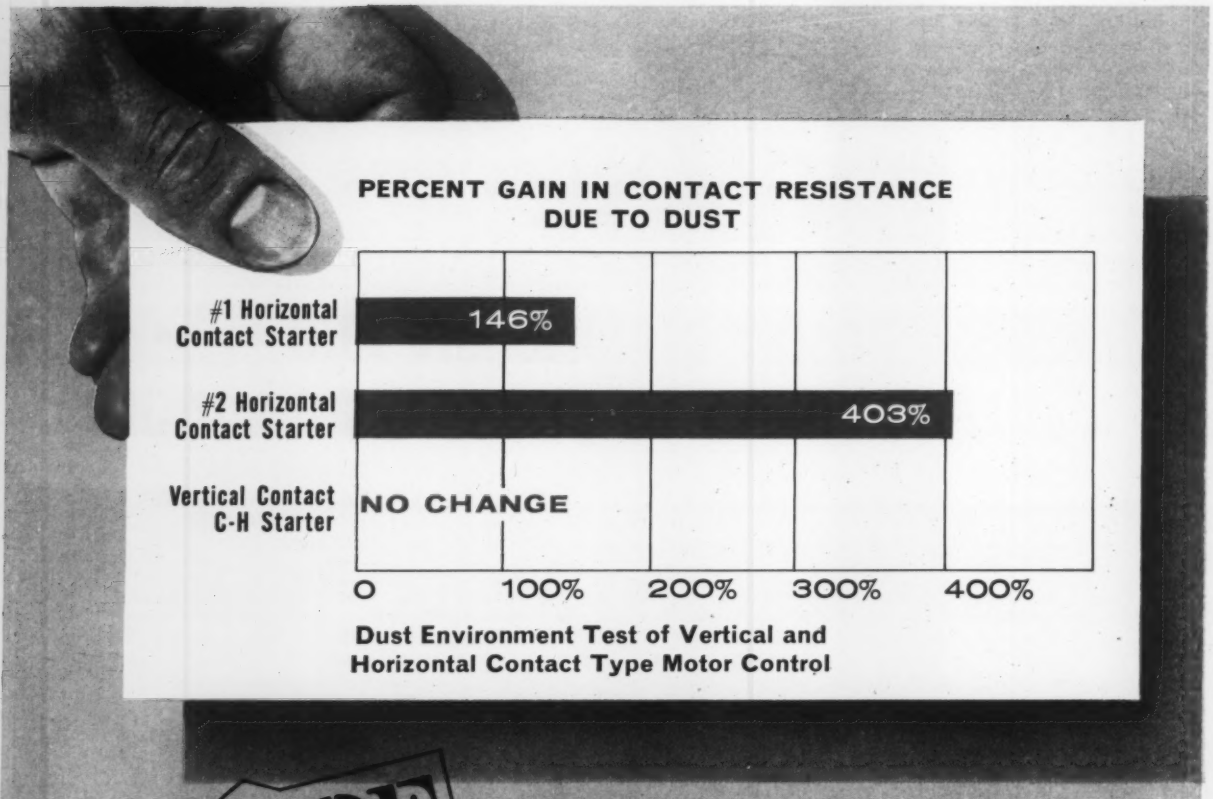

PROOF OF PERFORMANCE

Vertical *dust-safe* contacts keep Cutler-Hammer Three-Star Motor Control working better...working longer

Standard dust chamber used to compare performance of vertical and horizontal contact type motor starters in dust environments

"Dust can't collect on a vertical surface." This is a simple fact, but an important one to users of motor control. To function properly the contacts in motor control *must* stay clean, free from all forms of dust under all operating conditions. And because dust can't collect on a vertical surface, only vertical contacts are truly *dust-safe*. For proof look at the results of this test.

Both horizontal and vertical contact type motor starters were subjected to a dust environment for four hours. The vertical contacts proved their immunity to dust by maintaining a constant contact resistance. But the contact resistance of horizontal contacts skyrocketed, and as contact resistance increases so does heating, pitting and wear, resulting in rapid contact failure.

These are the facts . . . facts which show you why it's wise to standardize on Cutler-Hammer Three-Star Motor Control with vertical *dust-safe* contacts.

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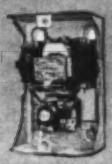

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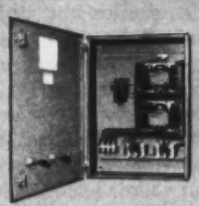

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Circle 421 on Page 19

Gas-Cooled Reactor Built in Modular Hull Section Will Be Inserted in Ship With Minimum Down Time

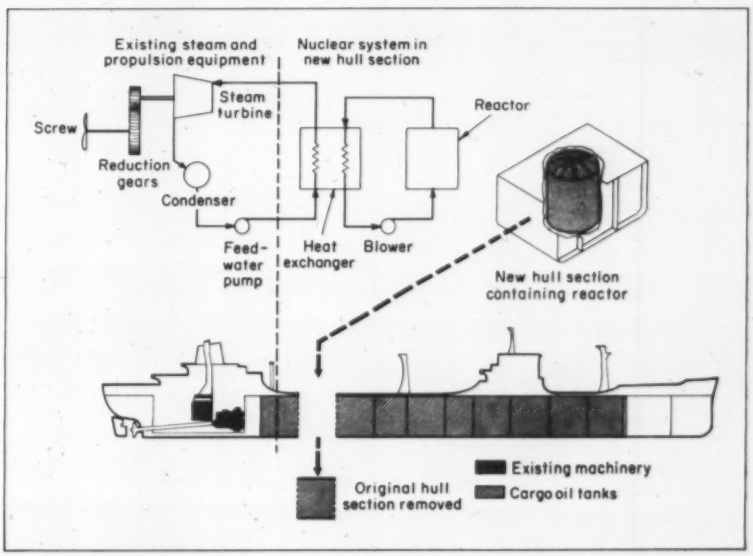
Fast Conversion Portends Off-the-Shelf Nuclear Power

WASHINGTON—A three-company co-op with experience in shipbuilding, ship operation, and nuclear energy will pool resources to get a nuclear-powered tanker on the high seas in double time. Their plan radically alters the usual procedure of building a prototype reactor, proving it out, building an entirely new reactor, and finally installing the second reactor in a brand new, specially designed ship.

Ford Instrument Co., Isbrandtsen Co., and Maryland Shipbuilding and Drydock Co. will build an advanced gas-cooled reactor and install it in an existing steam-turbine powered vessel of the *SS Hans Isbrandtsen* Class (32,791 tons). The existing main propulsion machinery in the ship will remain essentially intact. The reactor, its auxiliary equipment, and containment vessel will be erected in a newly constructed hull section, duplicating a section of the ship, and floated to a secluded area for tests. After the reactor has been shaken down, the hull section will be returned to the yards of Maryland Shipbuilding and "cut in" to the ship. One reactor will thus serve as both prototype and operating unit, and the ship will be in service until the reactor is ready. An added advantage of the plan: The ship's boilers remain intact, providing a standby system capable of full sea power. Only a small fuel oil reserve is required for this purpose.

The reactor to be used is helium cooled, graphite moderated, and fueled with stainless steel clad uranium dioxide pellets. Gas-exit temperature is 950 F. Superheated steam is generated at 640 psi and 850 F, consistent with modern marine practice. Because of the relatively low design pressures and temperatures (in both steam and gas), and the choice of an inert coolant, there is no requirement for exotic materials or sophisticated metallurgical techniques in the reactor.

The gas-steam system has several unique advantages for marine propulsion: It is not affected by pitch and roll; no radioactive steam can reach the turbine, and there will be no discharge of radioactive wastes. In addition, the reactor system has a slow thermal response, a negative



Main propulsion machinery remains intact in this new method of quickly converting ships to nuclear power. The economical reactor system has a simple primary loop and uses low-enrichment nuclear fuel.

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ATLAS

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temperature coefficient, and a low level of stored coolant energy.

Plans call for the reactor system to be completed and ready for testing in about three years. Sea trials will follow in six months.

Based on present estimates of net fuel costs, the nuclear fuel will be competitive with bunker oil by the third or fourth core loading. Since the ship's cargo oil capacity will be increased by approximately five per cent, early fuel cost will be largely offset by greater payload.

NBS Finds Torsion Tests Best For Spring-Wire Specification

WASHINGTON — The behavior of small-diameter spring wire can be more realistically determined from torsion tests than from the conventional tensile tests now used as a criterion. This is the conclusion drawn by the National Bureau of Standards from a series of tests done for the Springfield Armory on fatigue properties of small-diameter, high-carbon steel wire. Reversed torsion tests showed close agreement with data from performance of springs.

Previous work indicated that the customary tensile-strength specification is not an adequate measure of the expected performance of wire when it is coiled in helical extension or compression springs. At a nominal shear stress of 140,000 psi, fatigue life of springs coiled from vacuum-melted wire was shown to be about twice that of springs coiled from cold-drawn music wire having about the same carbon content (0.86-0.89 per cent). The difference is attributed to inclusions in the cold-drawn wire which acted as stress raisers.

The present work was to determine the metallurgical factors that influence the resistance of wire to fluctuating loads, and to devise a method of evaluating this resistance. Two fatigue-testing machines were used: An oscillating, torsion strain producer for straight wire, and a reciprocating machine for coiled springs. Excellent correlation between the two methods of testing was observed.

Circle 423 on Page 19

Successful Supervisor Studied For Key to Group Performance

Researcher Says Best Practice Differs from Company Policy

BATON ROUGE, LA.—"Highest producing managers and supervisors are using practices which differ in important ways from the operating procedures designated by their companies," says Rensis Likert, director of the University of Michigan Institute for Social Research. His statement is based on a series of 25 industrial studies conducted by the Institute. The more successful supervisor follows these procedures:

- Places primary emphasis on workers' human problems.
- Puts people who are congenial together.
- Trains workers not only for present job, but for next higher job.
- Establishes goals but leaves the worker free to meet them in his own way.
- Has confidence in his men.

In contrast, supervisors who are puzzled by their low productivity often follow these practices:

- Make subordinates adhere to detailed procedure.
- Put pressure on employees to step up production.
- Supervise workers closely.

Most supervisors are not able to adjust their point of view, Likert noted; a supervisor switched from a low-producing group to a high-producing one is not apt to alter his approach to his workers.

The studies reveal that traditional management theory largely ignores the importance of motivation to high-level performance. Group loyalty was stressed by Mr. Likert as a strong motivating force. It leads the individual to accept the goals of the group, to communicate more fully, and to seek the approval of leaders of the group. Each person in the organization should be the member of one or more closely knit groups. The leader of one group should be a member of at least one other group. Thus the organization can be knit together by overlapping group loyalties all the way up through top management.

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Bulletin R.A. 500 gives complete details and specifications on the Carter Rotary Torque Actuators. Every engineer and designer should have a copy. Send for yours today!

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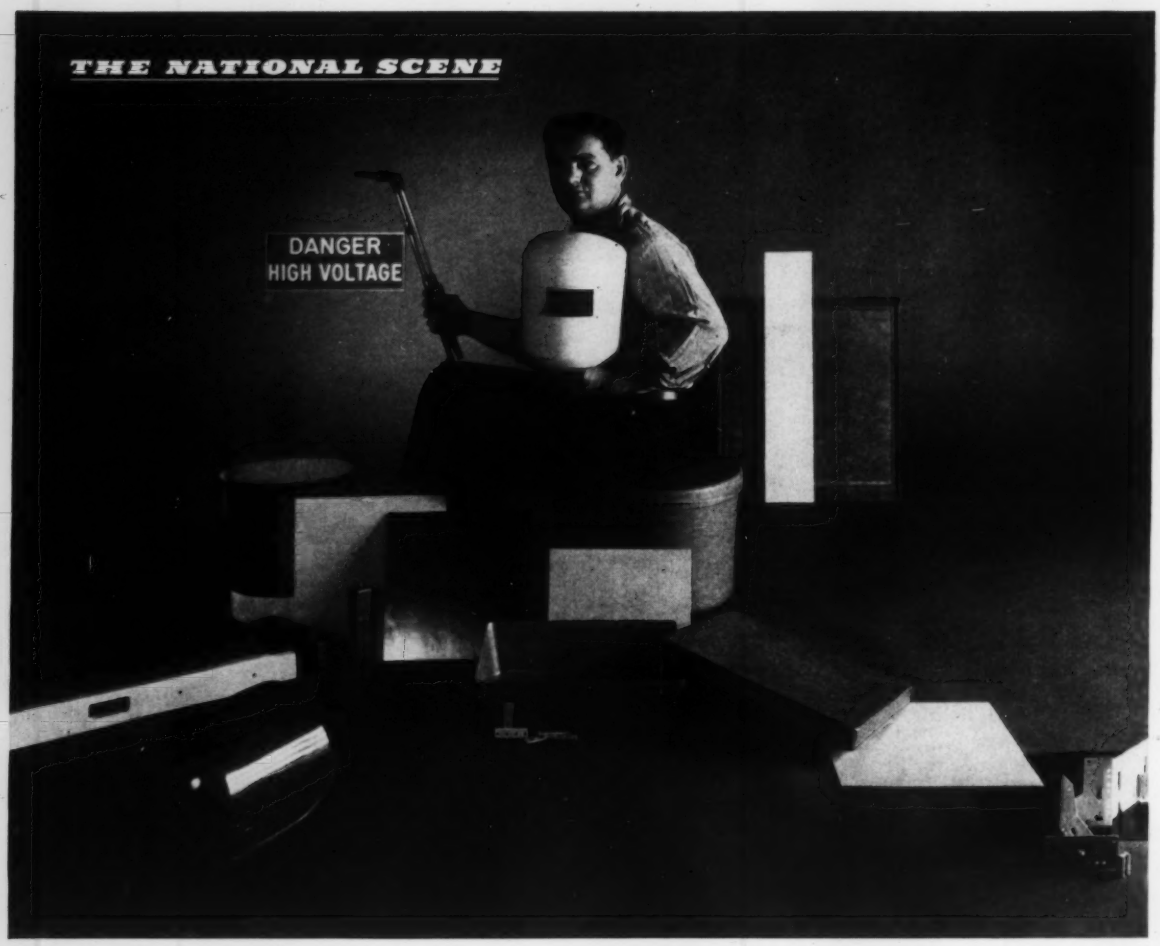
Circle 424 on Page 19



"YOUR NEXT POLYESTER COMPONENT: mold it or machine it?"

Get an unbiased answer from National because we work either way

Giving the designer facts to help make the *right* design decision faster is perhaps our best "product." Offering the broadest line of plastic materials and services permits us to give impartial help. Take polyester glass mat.

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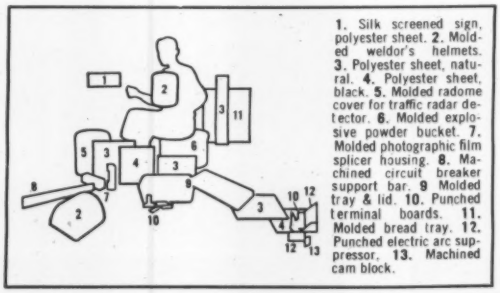
One more point. The problems inherent in machining polyester glass laminates have had a tendency to discourage some designers from considering it. We suggest that you bounce this headache out of your production facilities and into ours.

You see, we are interested in *both* your design and machining problems. Your component will be skillfully machined at one of our four complete, "service-located" fabricating facilities.

Send for our Polyester Technical Bulletin 1164. We'll be happy to include, also, data on the full line of National materials—over 100 grades. Write to National Vulcanized Fibre Co., Dept. **G-3,** Wilmington 99, Delaware.



1. Silk screened sign, polyester sheet. **2.** Molded weldor's helmets. **3.** Polyester sheet, natural. **4.** Polyester sheet, black. **5.** Molded radome cover for traffic radar detector. **6.** Molded explosive powder bucket. **7.** Molded photographic film splicer housing. **8.** Machined circuit breaker support bar. **9** Molded tray & lid. **10.** Punched terminal boards. **11.** Molded bread tray. **12.** Punched electric arc suppressor. **13.** Machined cam block.

Circle 425 on Page 19

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Fluorescent Square Matches Light Output of 100-w Bulb

Channeled glass plates are sealed together to make a fluorescent panel about 1 ft square by 1 in. thick. General Electric reports that its experimental panel produces more light than a 100-w bulb and uses about half the current. A wide variety of brightness and colors can be built into the glass panels for decorator effects, but GE says production of commercial models cannot be forecast yet.

Engineering Degree No Longer Passport to Good Job

Industry Seeks Only Top Men Says College Placement Director

ITHACA, N. Y.—The demand now is not for more engineers, but for better ones, according to Donald H. Moyer, Student Personnel Director of Cornell University's Engineering College. He says a selective demand for high-quality engineers began in 1958, and the trend, which has "real significance," promises to continue.

The prospects for engineering recruitment in 1959 are about the same as last year, Mr. Moyer states. "An accelerated business recovery could add to the demand, but with 10 per cent more graduates available in June, the net result is likely to be about the same." He says fewer companies have established recruiting dates than they had this time last year.

"Again this year, men in the top half of the class will have little placement problem. The below-average student will get a job, but it may not be the job he wants or where he wants it. He may even have to take the initiative and go beyond the confines of the college placement office to get a job."

This has not been as true during previous years, Mr. Moyer says. "Over 5000 companies have been scrambling annually for an average of between 20,000 and 25,000 engineering graduates, and in some of these years single companies have sought to hire from 500 to 1000, or more." For the past five years at Cornell, there have been between two and four times as many companies seeking engineers as graduates to fill the jobs.

"Reflecting this demand, starting salaries for the average Cornell engineer have risen 89 per cent, from $270 a month in 1950 to $510 in 1958," Mr. Moyer states.

(Advertisement)

DESIGN CONSIDERATIONS

Backlash in Indexing Mechanisms for High Production Machinery

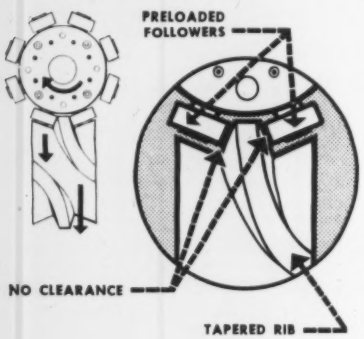
Backlash in indexing results in impact or shock loads that affect the efficiency of a machine and the quality of its product. Most indexing mechanisms have inherent characteristics that cause backlash and poor dynamic conditions and prevent the machine designer from taking full advantage of modern automatic feeds, tooling and methods that contribute so much to production economy.

Of the three principal indexing mechanisms, only one offers zero backlash and years of maintenance-free operation:

FERGUSON DRIVE

Continuously rotating cam includes a tapered rib, along which two preloaded bearing followers roll with no clearance between them and the rib. When the drive is in the rest, or dwell, position a straight portion of the rib locks the followers with *zero backlash* and an indexing accuracy of .001". Wear of the hardened cam is infinitesimal since it is subject to rolling friction only (many cams have been in use for more than 25 years). Followers are rated for a minimum of 8,000 hours precision operation at speeds up to 2,000 indexes a minute. If followers wear after this time, they can be replaced, thus renewing the drive for a like period.

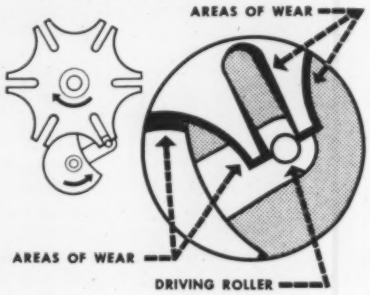
FIG. 1 FERGUSON DRIVE



GENEVA DRIVE

A geneva drive consists of a slotted wheel and a driver with a driving roller. Indexing occurs when the roller crashes into the slot, causing the wheel to move one increment. There must be clearance in the slot to allow passage of the roller. With clearance there must also be backlash. Impact loading, resulting from the inherent backlash, causes the slots to wear quickly and the backlash becomes progressively more severe. Operating speeds must be limited to contain the dynamic forces generated by backlash, even then, genevas require replacement with great frequency and downtime for maintenance is a major problem.

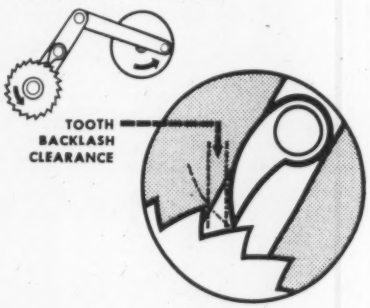
FIG. 2 GENEVA DRIVE



RATCHET & CRANK

Tooth clearance backlash causes the pawl to strike the ratchet teeth with considerable impact when indexing begins and vibratory forces are extreme. After mid stroke, the arm stops the pawl gradually but the wheel must be stopped by frictional braking or by positive means. Friction brakes allow over-travel and inaccuracy of index. They wear quickly and require excess downtime for maintenance. Because positive stopping is instantaneous, impact and rebound action of the wheel is tremendous. Neither method of stopping is satisfactory from the standpoint of low maintenance requirements or controlled dynamic conditions. Sustained high speed production is virtually impossible.

FIG. 3 RATCHET & CRANK



• SEND FOR CATALOG

Zero backlash is only one inherent advantage of the Ferguson Drive. Others are explained in an easy-to-use catalog containing load ratings and dimensions of many standard units, drawings and installation photos. There is a copy for every design engineer . . . Write **FERGUSON MACHINE CORPORATION, 7818 MAPLEWOOD INDUSTRIAL COURT, ST. LOUIS 17, MO.**

ENGINEERING NEWS

High-Voltage Experts Predict 650-kv Power Lines by 1975

They Also Declare DC Too Costly to Replace AC

NEW YORK — Electricity may be transmitted at 650,000 v sometime in the 1970's according to two General Electric Co. high-voltage experts. P. A. Abetti and S. B. Crary spelled out the present and future picture of extra-high-voltage (ehv) transmission during the recent AIEE Winter Meeting in New York.

"In the next decade," they said, "there will be continued and rapid expansion of ehv systems in this country at 345 kv. In addition, 460-kv systems will be built, probably in 1962-63. There appears to be little justification for introducing 400 kv at this time, however. Instead, much effort will be given to improving the efficiencies and capabilities of present and new ehv systems."

The second big step in voltage—to 650 kv—may be required in the late '70's. Even if there appears to be no further economic advantages in increasing the voltage levels above 450 kv, planning for the use and development of the higher voltages can be expected to open new opportunities to obtain better integrated and more efficient systems, the engineers said.

AIEE members were also told that ac is here to stay, as far as overhead transmission of power is concerned.

A. J. Wood, S. B. Crary, and C. Concordia, also of General Electric Co., said that "even with the most optimistic terminal-equipment cost estimates, based on published work of various European investigators, it does not appear that dc overhead transmission will be utilized economically to any extent in this country.

The speakers explained that the capabilities and economics of a dc overhead power transmission system make it suited for long-distance transmission of large blocks of power. Minimum transmission of approximately 350 miles is required, however, to overcome the economic advantage of presently available ac systems.

Circle 427 on Page 19

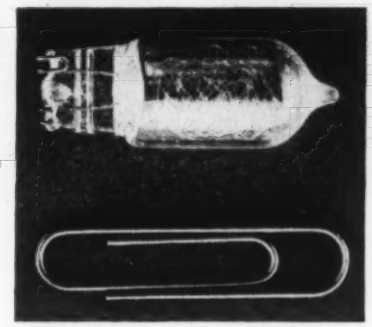
They listed these advantages of dc transmission:

- Lower line costs
- Flexibility of asynchronous ties
- High circuit loadings

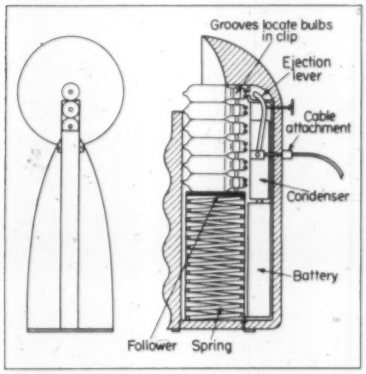
Ac, on the other hand, has the advantage in lower terminal equipment costs, inherent flexibility, and proven reliability of systems and equipment.

A study of the economics of conductor sizes for dc overhead transmission, they stated, indicates that relatively large conductors would be required in order to insure a reasonable power-transmission efficiency and line-voltage drop.

For Clip-Loaded Flashguns



All-glass photoflash lamp with grooved base to fit plastic magazines, makes possible the design of "clip-loading" automatic flashguns similar to artist's conception shown below. Although about the size of a .32-cal bullet, the lamp gives 7000 lumen-seconds of light. In a 2-in. diam reflector it does the same job as the larger M2 in a standard 3-in. diam reflector. General Electric, Cleveland, expects to market the lamp next April. Plans call for packaging in a plastic strip for multiple loading in magazine flashguns.



Circle 428 on Page 19→

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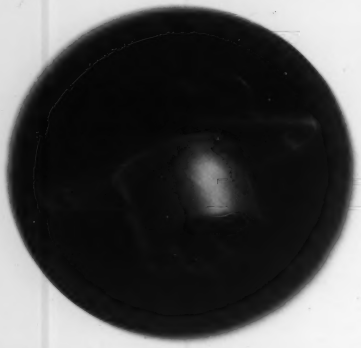

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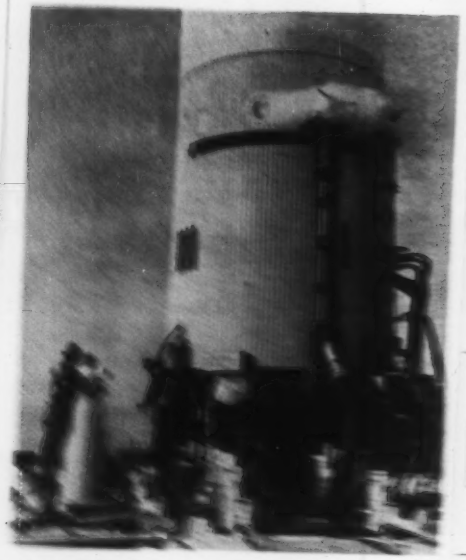
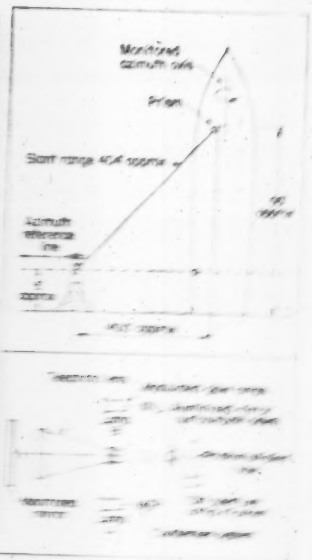
mount "mileage"





Light Beam Aligns Guidance System of Poised IRBM

[illegible] building platform in the nose of the Jupiter IRBM is part of [illegible] precision recording unit by Perkin-Elmer Corp., Norwalk, Conn., operates the electronic part of the circuit with [illegible] on one [illegible] gyro beams. Sources of the light are [illegible] prism assembly, in opposite [illegible] lens and [illegible] which [illegible] through an objective lens to [illegible] mirror fixed to the inertial guidance [illegible] Even slight errors in alignment of the mirror cause one of the [illegible] beams to [illegible] through [illegible] of the [illegible] of the receiving prism. This [illegible] to signal [illegible] unit and indicate the amount of error. [illegible] records during [illegible] missile [illegible] is discharged. Data shown [illegible] records can [illegible] with [illegible] missile [illegible] during [illegible] ability

Plastic Antenna Cuts Weight of Ships' Radar

[illegible] one of the [illegible] missile [illegible] new nonmetallic plastic [illegible] evolved by [illegible] aviation [illegible] radar in [illegible] with [illegible] antenna [illegible] reliability [illegible] plastic [illegible] [illegible] [illegible]

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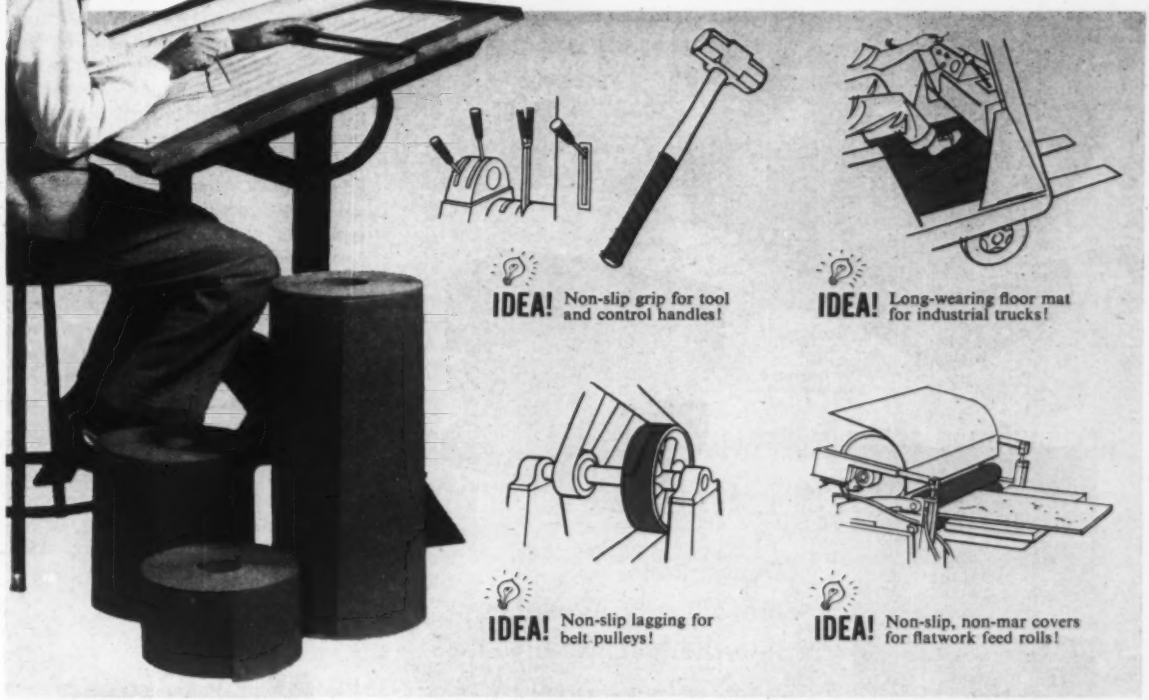

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VERSATILE! Pliable "SCOTCH-TRED" will conform smoothly to almost any surface; can be cut with scissors, knife, or die; pressure-sensitive adhesive sticks at a touch to any surface. Available in ¾" x 24" strips; 9" squares; bulk 96-foot rolls from 4" to 36" in width. Complete information and prompt service available through local wholesalers. Contact your nearest 3M office.

See our insert in Sweet's Product Design File, 4b/Mi.

"SCOTCH-TRED" and "SAFETY-WALK" non-slip surfacings are manufactured in U.S.A. by 3M Co., St. Paul 6, Minn. Export: 99 Park Ave., New York 16. Canada: London, Ontario.

MINNESOTA MINING AND MANUFACTURING COMPANY

3M COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

FOR EXTRA HEAVY-DUTY NEEDS, 3M's "SAFETY-WALK" is often used. A mineral coated fabric that is practically indestructible, "SAFETY-WALK" stands up well under abuse and punishing traffic.

scotch • tred BRAND
Resilient NON-SLIP SURFACING

SEND FOR FREE SAMPLE . . . USE THE COUPON

3M CO., Dept. TK-39
St. Paul 6, Minn.

☐ Rush free sample of "SCOTCH-TRED".
☐ Send sample and information about "SAFETY-WALK".

Name_____
Firm_____
Address_____
City_____ Zone____ State_____

vibration isolators

give more mount "mileage"

MB ISOMODE* mounts break endurance records. Despite heat, road shock and hard operating conditions in bus service, engine mounts removed for critical inspection after 132,000 miles were still good. To such durability add the superior vibration isolation afforded by a mount that controls vibratory motion in all directions.

MB concentrates on standard mounts which are actually in the special performance class. If you have a problem, avail yourself of our 20 years of experience. Send for Bulletin 616A which tells more.

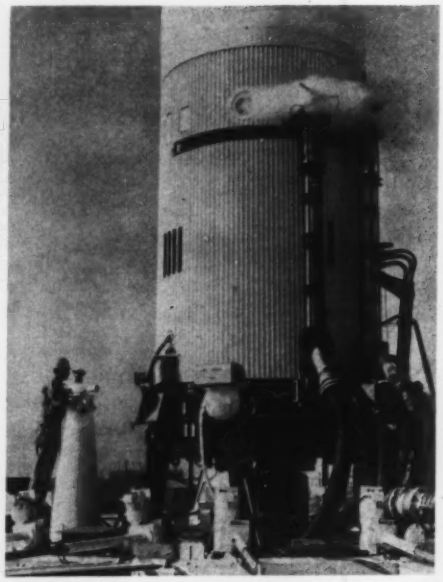
MB MANUFACTURING COMPANY

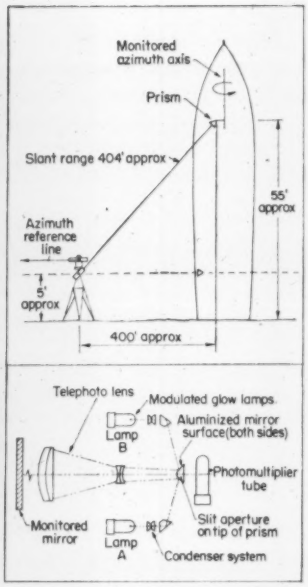
A DIVISION OF TEXTRON INC.

1056 State Street

New Haven 11, Connecticut

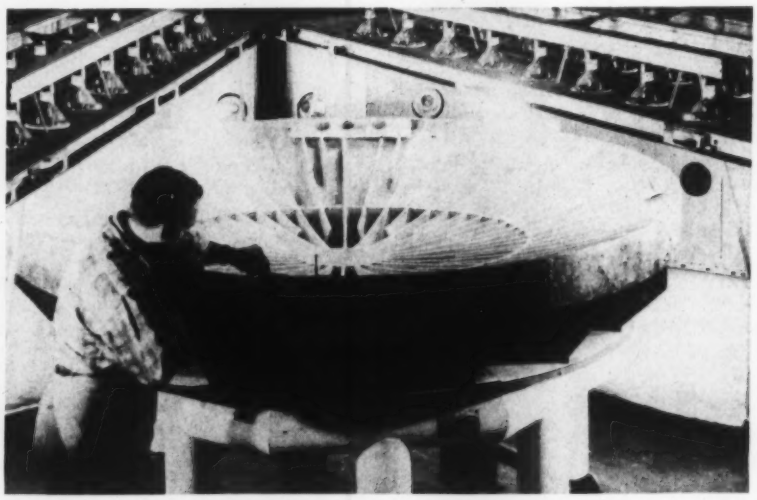
Circle 429 on Page 19





Light Beam Aligns Guidance System of Poised IRBM

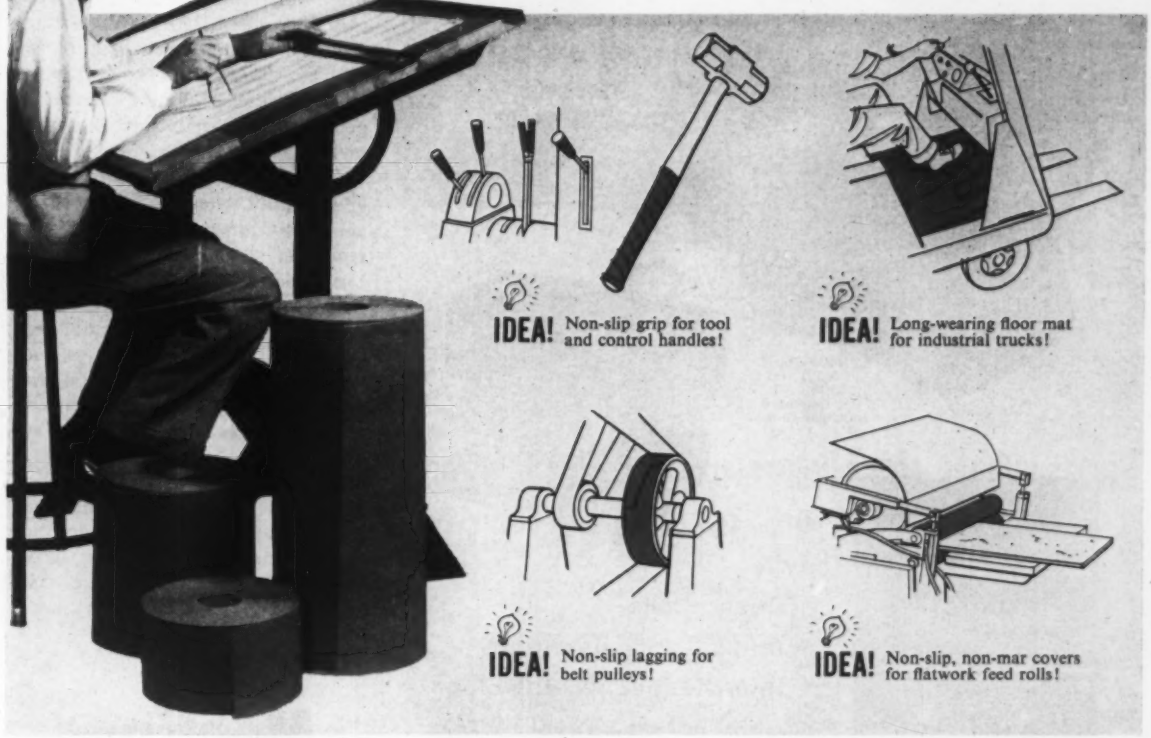
Inertial guidance platform in the nose of the Jupiter IRBM is held on course by a closed optic-electronic circuit. A precision theodolite built by Perkin-Elmer Corp., Norwalk, Conn., operates the electronic part of the circuit with information read from two reflected light beams. Sources of the light are 400-cycle lamps operating in opposite phase. Each lamp contributes a light beam which travels through an objective lens to strike a mirror fixed to the inertial-guidance reference platform. Even slight errors in alignment of the mirror cause one of the reflected beams to pass through a slot in the nose of a receiving prism. Phase is identified to signal "left" or "right" and indicate the amount of error. Standard theodolite focused on mirror in missile nose is diagramed. Photo shows short-range theodolite used with mirror at missile base during poor visibility.



Plastic Antenna Cuts Weight of Ships' Radar

Tracking radar for the Tartar shipboard missile will use new lightweight plastic antennas. Developed by Republic Aviation Corp., the 8-ft diam units are strengthened with specially designed plastic radial ribs and sprayed with a metal coating. Plastic used is called Trulite—also developed by Republic.

Versatility plus application ease make "SCOTCH-TRED" a stimulating IDEA material for more creative product design



IDEA! Non-slip grip for tool and control handles!

IDEA! Long-wearing floor mat for industrial trucks!

IDEA! Non-slip lagging for belt pulleys!

IDEA! Non-slip, non-mar covers for flatwork feed rolls!

Amazing new "SCOTCH-TRED"—resilient non-slip surfacing—IDEA material of a thousand uses!

FUNCTIONAL! Durable "SCOTCH-TRED" has a textured surface with high capabilities in slip and skid elimination. Resilient under foot or under pressure . . . extra long-wearing . . . non-sparking. Easily cleaned with soap and water.

DECORATIVE! Modern soft decorator colors—beige, gray, black—harmonize with any scheme. Pleasantly textured surface is soft, pliable, brings new comfort to safety conditioning.

VERSATILE! Pliable "SCOTCH-TRED" will conform smoothly to almost any surface; can be cut with scissors, knife, or die; pressure-sensitive adhesive sticks at a touch to any surface. Available in ¾" x 24" strips; 9" squares; bulk 96-foot rolls from 4" to 36" in width. Complete information and prompt service available through local wholesalers. Contact your nearest 3M office.

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scotch•tred BRAND *Resilient* NON-SLIP SURFACING

SEND FOR FREE SAMPLE . . . USE THE COUPON

3M CO., Dept. TK-39
St. Paul 6, Minn.

☐ Rush free sample of "SCOTCH-TRED".
☐ Send sample and information about "SAFETY-WALK".

Name_____

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Choose Right...

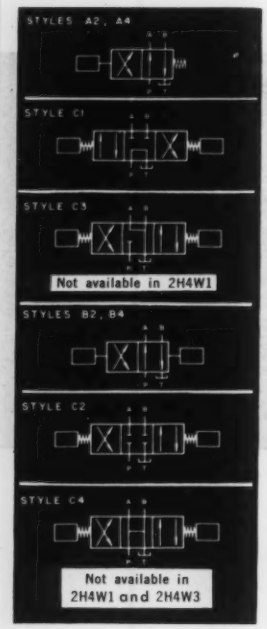
Choose Pathon

4 Way Directional Control Valves

#2H4W1-S
¼" N.P.T. Ports
1¼ GPM
Direct Solenoid
2000 psi service

#2H4W3-S
⅜" N.P.T. Ports
8 GPM
Direct Solenoid
2000 psi service

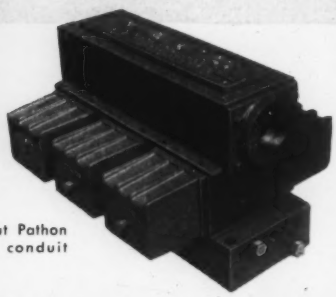
#2H4W6-PS
¾" N.P.T. Ports
20 GPM
Pilot Operated
2000 psi service



They're

- **Dependable**
- **Immediately Available**
- **Interchangeable with other good valves**

Stock valves are equipped with 115 volt/50-60 cycle solenoids, however 230 volt/50-60 cycle, 460 volt/50-60 cycle, and others, are available on short notice. Both bottom plumbed and side plumbed subplate are available. Write for full information.



Inquire about Pathon valve and conduit manifolds.

Pathon MANUFACTURING COMPANY

C-59 **3823 PACIFIC AVE. • CINCINNATI 12, OHIO**

FLUID OPERATED AND CONTROL EQUIPMENT

Code Finally Established For Bearing Identification

NEW YORK—After 13 years of committee work, ASA Sectional Committee B54 has finally completed its mission: An identification code for antifriction bearings.

An alpha-numerical system has been established to describe the main features of standard bearings —tolerances, lubrication, and physical features. After processing through usual channels, the new standard is expected to be published sometime in 1959.

According to ASA, the code will give a quick, concise, and economical means of transmitting an engineering description of ball and roller bearings between user and manufacturer. The bearing manufacturers have stated that they will code their present lines of production to the new identification system as soon as it is approved.

Development of the American Standard has been tied directly to work on the same subject in the International Organization for Standardization (ISO). According to ASA, there is almost 100 per cent agreement between the proposed ISO Code and the new American code.

Meetings

AND EXPOSITIONS

April 5-10—

Nuclear Congress, composed of Nuclear Engineering and Science Conference, Hot Laboratories and Equipment Conference, Atomic Energy in Industry Conference, and the AtomFair, to be held at the Public Auditorium, Cleveland. Additional information can be obtained from International Atomic Exposition, Architects Bldg., Philadelphia 3, Pa.

April 6-10—

American Welding Society. Annual Welding Show and Convention to be held in Chicago. Technical meetings will be at the Hotel Sherman Monday through Friday;

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the show will be at the International Amphitheatre Tuesday through Thursday. Further information is available from society headquarters, 33 W. 39th St., New York 18, N. Y.

April 7-10—

Conference on Numerical Control of Machines in Production Processes presented by the Schools of Engineering and the Div. of Adult Education, Purdue University, Lafayette, Ind. Program will be at the Memorial Center.

April 13-17—

American Foundrymen's Society. Castings Congress and Engineered Castings Show to be held at Hotels Sherman and Morrison, Chicago. Additional information can be obtained from AFS, Golf and Wolf Roads, Des Plaines, Ill.

April 13-17—

American Management Association. National Packaging Exposition and Conference to be held at the International Amphitheatre and the Palmer House, Chicago. Further information is available from AMA headquarters, 1515 Broadway, New York 36, N. Y.

"You're falling behind again, Ernie."

April 14-15—

Conference on Industrial Instrumentation and Control to be held at Illinois Institute of Technology, Chicago. Conference is sponsored by Armour Research Foundation in

GRADE A ACCURACY... PREMIUM GAUGE CONSTRUCTION AT THE PRICE OF GENERAL PURPOSE GAUGES...

Now you can buy hydraulic pressure gauges that are sturdier, more accurate, and have the specific quality features you need . . . yet cost you no more than you'd pay for general purpose gauges. These 5090 Series gauges are part of the new USG "A" Line, specifically designed to withstand the frequent shocks, pulsations, and mechanical vibrations—such as found in the operation of hydraulic presses, Diesel or oil field equipment, and the like.

MEET A.S.A. GRADE A STANDARDS—Available in sizes from 3½ to 12 inches, for pressures up to 10,000 psi, these gauges are guaranteed accurate within 1% of scale range for middle (working) half of scale—1½% for remainder.

EXTRA RUGGED CONSTRUCTION—For the severe service conditions found in hydraulic pressure measurements, the 5090 Series gauges embody such design points as:

a **Top quality, 403 stainless steel Bourdon tubes,** produced and quality-controlled in USG's own plant—your assurance of long, dependable service.

b **Extended life of movement,** through wide meshing gears, even under most severe conditions of pulsation and continuous service.

c **Protection from shock on movement,** through spring-loaded link, when pointer returns to zero with sudden release of pressure.

d **Sustained accuracy, reproducibility, and ease of maintenance** through use of USG's patented ARC-LOC movement (stainless steel pinion, nylon-faced stainless steel segment, and deep stainless steel bushings mounted in stainless steel plates.)

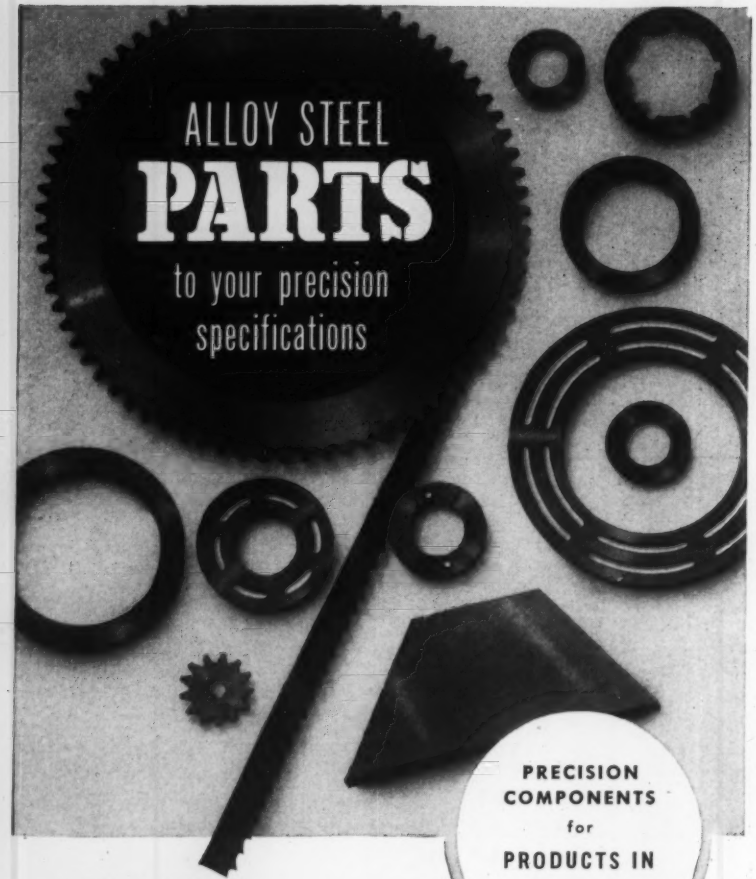
Find Your Nearest Distributor In The 'Yellow Pages'

PRICE, IT'S LOW!—You'll have to see the new Series 5090 gauge to believe that it's available without a premium price. Ask your U. S. Gauge distributor for a demonstration today, or write for a copy of new Catalog 305 which describes USG's complete line of industrial gauges.

UNITED STATES GAUGE
DIVISION OF AMERICAN MACHINE AND METALS, INC., SELLERSVILLE, PA.

USG

Circle 432 on Page 19



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Call on ATKINS' complete production facilities and more than 100 years' design and manufacturing experience to supply *flat alloy-steel* parts for your product.

ATKINS will produce parts of any size or hardness, machined to any desired finish or tolerance . . . for automotive, aircraft or industrial engines and frames . . . machinery, presses and many other items of equipment. Typical ATKINS parts are clutch plates, valve discs, torsion bars and springs; flat steel machine parts; bars, spacer rings and washers; discs, knives and blades for any cutting or scraping operation.

Prompt delivery to meet your production schedule. Engineering service available.

Address inquiries, including full specifications and/or blueprints, to

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ATKINS Silver Steel SAWS

Our SECOND CENTURY of Service to American Industry

co-operation with the Professional Group on Industrial Electronics of the Institute of Radio Engineers. Further information can be obtained from M. J. Jans, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

April 18-22—

American Society of Tool Engineers. Annual Meeting to be held at the Schroeder Hotel, Milwaukee. Further information can be obtained from society headquarters, 19700 Puritan Ave., Detroit 38, Mich.

April 20-22—

Metal Powder Industries Federation. Fifteenth Annual Meeting and Powder Metallurgy Show to be held at the Sheraton-Cadillac Hotel, Detroit. Further information can be obtained from headquarters of MPIF (formerly Metal Powder Association), 130 W. 42nd St., New York 36, N. Y.

April 21-23—

American Society of Lubrication Engineers. Fourteenth Annual Meeting and Lubrication Exhibit to be held at the Hotel Statler, Buffalo, N. Y. Additional information can be obtained from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

April 25-30—

Scientific Apparatus Makers Association. Annual Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Additional information is available from association headquarters, 20 N. Wacker Dr., Chicago 6, Ill.

April 29-May 1—

American Society of Mechanical Engineers. Metals Engineering Div. Conference to be held in Albany, N. Y. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

May 6-8—

Institute of Radio Engineers. Seventh Region Conference and Electronics Exhibit to be held at the University of New Mexico, Albuquerque. Additional information can be obtained from conference headquarters, P. O. Box 3262, Albuquerque, N. Mex.

Circle 433 on Page 19

May 11-13—

Joint Automation Conference, sponsored by American Society of Mechanical Engineers, American Institute of Electrical Engineers and Institute of Radio Engineers, to be held at the Pick-Congress Hotel, Chicago. Further information can be obtained from F. D. Snyder, Westinghouse Electric Corp., 40 Wall St., New York 5, N. Y.

May 18-20—

Instrument Society of America. Fifth Annual Symposium on Instrumental Methods of Analysis to be held at the Shamrock-Hilton Hotel, Houston, Tex. Further information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

May 20-22—

Society for Experimental Stress Analysis. Spring Meeting to be held at the Sheraton Park Hotel, Washington, D. C. Additional information is available from R. O. Belsheim, 2475 Virginia Ave. N.W., Apt. 514, Washington 7, D. C.

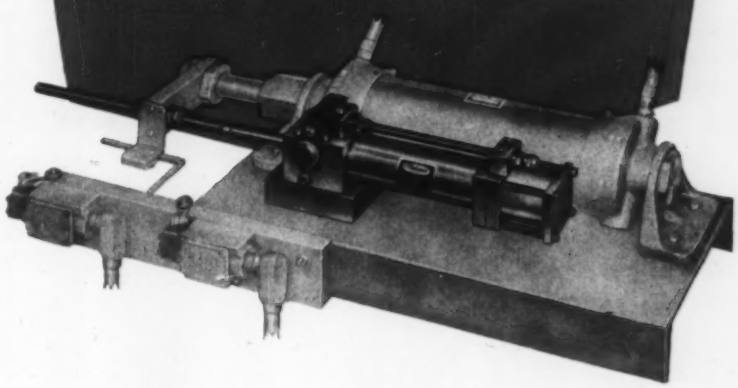
May 25-28—

Design Engineering Show and Conference to be held at Convention Hall, Philadelphia. Conference is sponsored by the Machine Design Div. of ASME. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

"I think poor Beasley has just about had it."

Now—Hydraulic Smoothness and Control from your own Air Cylinder plus a

VERI-TROL
TRADE MARK
Hydraulic Checking Cylinder



Designed for use with conventional air cylinders, VERI-TROL hydraulic checking cylinders smooth out stroke variations due to the compressibility of air under irregular load conditions. They're ideally suited for use with air cylinders operating tool or work-piece feeds, precise positioning devices, or wherever you need a smooth, uniform work stroke at any desired pre-set speed. VERI-TROL features (patents applied for) include:

- ACCURATE SPEED CONTROL is dial-set, load-compensated to assure uniform stroke speed even with irregular loads.
- BUILT IN "SKIP," "STOP" OR "SKIP-STOP" controls optional.
- VISIBLE OIL RESERVOIR, easy to refill.
- 2,000 LB. CHECKING CAPACITY on out stroke, free return.
- 2", 4", 6", 9", 12", 15" and 18" checking stroke lengths.

Take the bumps and jumps out of air cylinder operation — install VERI-TROL checking cylinders wherever you want smooth, accurately-controlled stroke speed. Write now for free data bulletin; please address Dept. E-3.

Modernair CORPORATION
400 PREDA ST.,
SAN LEANDRO, CALIF.

36

MEMBER OF NATIONAL FLUID POWER ASSOCIATION

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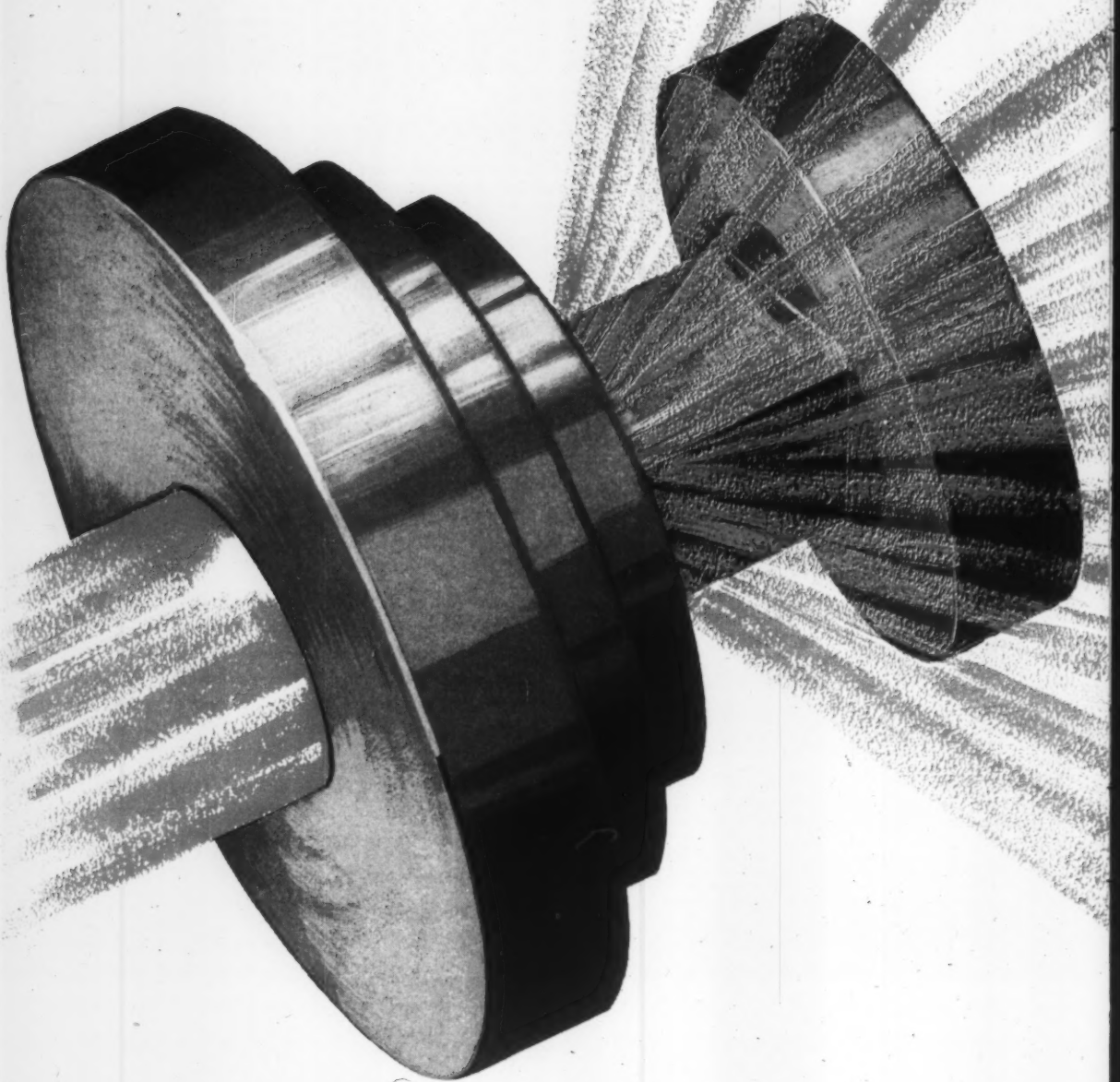
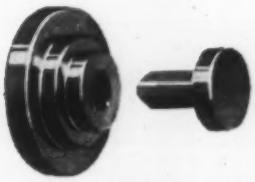
FOR THE MACHINERY PART



THAT TAKES THE BEATING



Liquids forced at high pressure through restricting valves—of HAYNES STELLITE alloy! That's the modern way by which hundreds of products are homogenized today, to make better dairy, chemical, food, and textile products, to name a few.

HAYNES alloys have been a standard material for homogenizer valves for 25 years. Valves that remain free from roughness, porosity, sharp corners, pits. Valves that retain their dimensions where pressures may reach 15,000 psi, and liquid velocities exceed 30,000 ft. per minute. Valves that keep products clean and free from contamination and give long service despite corrosive and abrasive conditions.

If design and production in your field call for tough metal parts, look into HAYNES alloys. There are more than 15 to choose from including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist practically any condition of wear, heat, or corrosion. For more information write for descriptive literature.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of
Union Carbide Corporation
Kokomo, Indiana

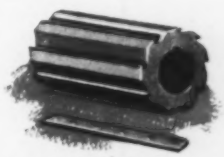
UNION CARBIDE

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS

Chuck inserts of HAYNES STELLITE alloy last up to 50 days—2 shifts daily—holding heavy pieces during a cut-off operation.

Seam rollers on milk-can machines turn out 2 to 3 times as many cans now that the rollers are made of HAYNES STELLITE alloy.



Cutters and bed knives made of HAYNES STELLITE alloy stay clean and sharp for years while pelletizing extruded polystyrene.

Circle 435 on Page 19

TAKE THIS SHIRT-SLEEVE SHORT-CUT TO MORE EFFICIENT ASSEMBLY!

Are you open-minded about methods of permanent fastening? If so, it will pay you to call in your nearby Thomson Fastening Man. Ask him to look at your new-product sketches or old-product assembly lines. Chances are, he can tell on the spot whether you can speed production or cut costs with time-tested automatic positioning and fastening techniques. If not, he'll pass your problem, drawings or samples along to his home-office engineers who know when riveting beats stapling, welding, cementing and other permanent fastening methods.

Your Thomson Fastening Man sells by giving shirt-sleeve service. He's more interested in solving fastening problems than in selling rivets. So, use him freely as your direct contact with 74 years of fastening experience. Why not make a date with him soon? Write today to Dept. MD.

See us at the Western Metals Congress
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March 16-20 **Booth #725**

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Please direct inquiries to advertiser, mentioning MACHINE DESIGN

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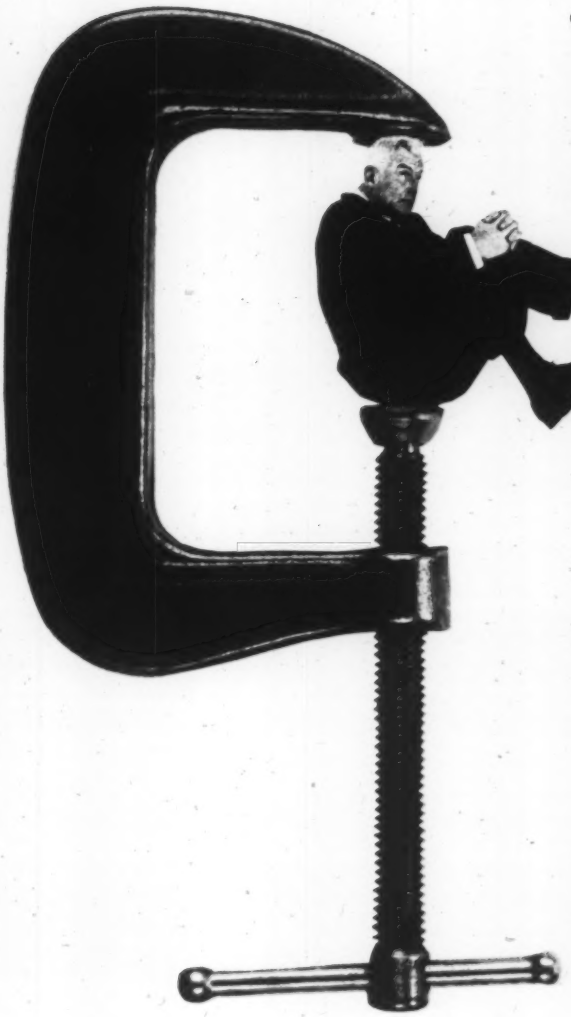


"the fast way out of today's profit squeeze

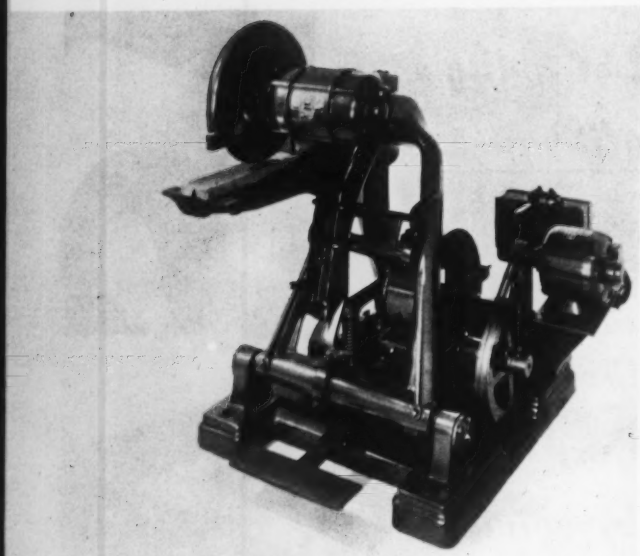
is through the use of more efficient materials which cost less to machine and fabricate, yet produce a better product..."

i.e. Federated Tenzaloy the high-strength aluminum alloy that needs no heat treatment

ASARCO

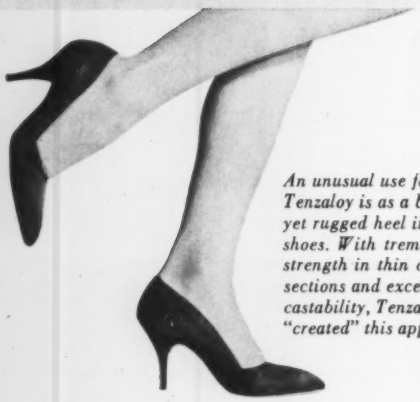
SEE NEXT PAGE

Federated TENZALOY



The vibration, strain, and abuse undergone by the movable arm of this cut-off saw calls for Tenzaloy, more and more the most qualified material for hard usage applications of this type.

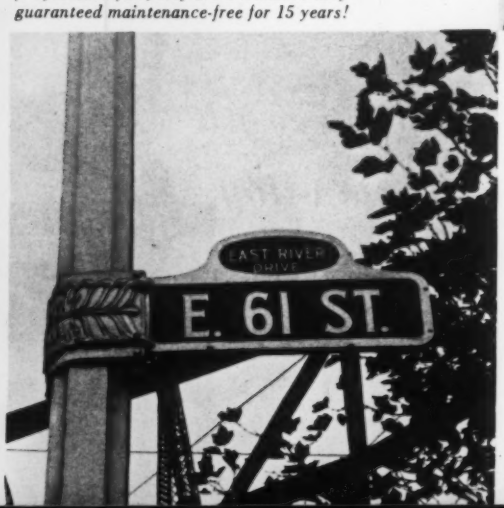
Tenzaloy replaced a more expensive alloy in casting this airplane turntable when increasing size and weight of today's planes required a casting so large (4000 pounds!) that no heat treating equipment could handle it.



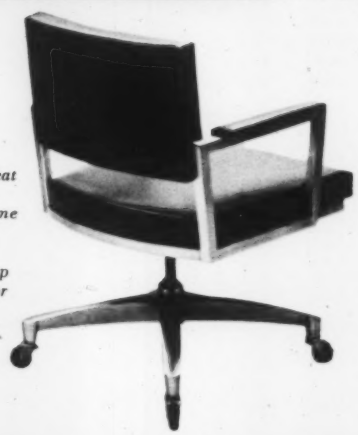
An unusual use for Tenzaloy is as a beautiful yet rugged heel in women's shoes. With tremendous strength in thin cross sections and excellent castability, Tenzaloy "created" this application!

Today's cooks choose shiny lightweight utensils cast in Tenzaloy over old style cast-iron pieces which often left ugly rust streaks. With corrosion-free Tenzaloy, there's no chance of contamination—ever!

Corrosion engineers expect these New York street signs to stay rust-free and shiny for years. In fact, they are unconditionally guaranteed maintenance-free for 15 years!

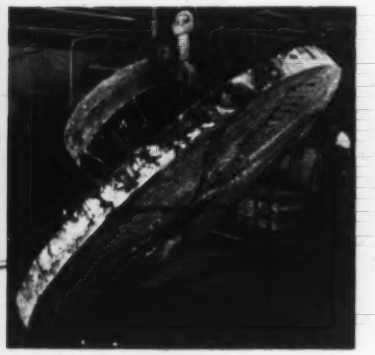


Tenzaloy contributes great strength in thin cross sections to these handsome modern chairs. Its castability in single-piece complex shapes, opens up wide new possibilities for the furniture designer.



the self-aging aluminum alloy gives you castings with greater strength–

for less! Tenzaloy the self-aging aluminum alloy needs no heat treatment! If your aluminum castings are too large or too intricate for heat treatment, if your heat treating facilities are limited, if you need superior strength than you get from ordinary heat-treated alloy, specify "Federated Tenzaloy" developed by Federated to meet the need for a superior aluminum alloy that ages at room temperature. Tenzaloy eliminates rejects due to warpage, expansion, and internal stresses caused by quenching. Tenzaloy finished properties are stable, proved by conclusive test data over a ten-year period. No special foundry techniques are required. No fluxes. Castability is excellent with sand cast and plaster molds and many permanent molds. Tenzaloy will not "grow," produces corrosion-resistant castings with excellent polishing characteristics and anodizes clear white.



Unlike heavy old-style fixtures, awning hardware cast in lightweight Tenzaloy defy rust and outdoor wear. No painting needed; the bright finish is permanent!

Specify Federated Tenzaloy for:

1. High "as cast" properties—no heat treatment required to get the properties of heat-treated castings.
2. High yield strength—Tenzaloy can be stressed beyond other high-strength, non-aging alloys.
3. Excellent ductility, particularly before aging—if it is desired to cold work or form castings, it should be done as soon as possible after casting, preferably within a day or so.
4. High impact and shock resistance.
5. Excellent machinability—better than the common aluminum-copper alloys. Machinability maximum after aging several weeks, or after artificial aging at 250°F. If machine operations are performed too soon after casting, some tendency to gumminess will be experienced.
6. Superior corrosion resistance—equivalent to the aluminum-silicon alloys.
7. Excellent polishing characteristics—will produce silvery-white castings that take a high polish.
8. Takes a white anodized finish—castings can be dyed all available colors; porosity-free surfaces are essential for satisfactorily utilizing current commercial dyeing procedures.
9. No special foundry technique required—handles like any other aluminum alloy. Heat to required temperature, skim and cast. Magnesium additions normally not required.
10. Good castability—produces sharp impressions, clean castings.
11. Permanent molds can be used—thin-walled, restrained, intricate shapes should be avoided.
12. Plaster molds can be used—properties superior to other aluminum alloys will be obtained. Excellent castability.
13. No fluxes needed—skimming alone is sufficient. A flux may be used to assist in dross removal where necessary. All stirring and excessive turbulence during pouring should be avoided.
14. Dimensionally stable—Tenzaloy does not grow as do other aluminum alloys containing copper and silicon as major alloying elements.
15. Internal stresses normally found in high-strength heat-treated castings are not present because quenching is not required.
16. Can be brazed by standard techniques used for wrought alloys; oven or flux-dip method.

COMPOSITION AND COVERING SPECIFICATIONS

The nominal composition of Tenzaloy is: Copper—0.8%, Zinc—8.0%, Magnesium—0.4%, Aluminum—balance.

Tenzaloy is covered by SAE 315, ASTM Specifications B179-58 alloy ZC81A-B for Ingot; B108-58T alloy ZC81B for Permanent Mold: and B26-58T alloy ZC81A for Sand Casting. Tenzaloy is covered in Government Specifications by MIL-A-17129 (Ships) Class 8, MIL-A-12033 (ORD) alloy ZC81A, and Federal Specification QQ-A-6016 Class 22M.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

Ready to talk TENZALOY?

(or about any one of the many others of Federated Metals' complete line of aluminum casting alloys)

Write for Tenzaloy Bulletin No. 103, Aluminum Casting Alloys Handbook Bulletin No. 101. Federated Metals Division, 120 Broadway, New York 5. Or the Federated Sales Office, or plant near you

ALTON, ILLINOIS
Alton Phone: Alton 5-2511
St. Louis phone: Jackson 4-4040

BALTIMORE 24, MARYLAND
Highland & Eastbourne Aves.
Phone: Orleans 5-2400

BIRMINGHAM, ALA.
416 Dalton Drive
Phone: Fairfax 2-1802

BOSTON 16, MASS.
Statler Office Bldg.
20 Providence Street
Phone: Liberty 2-0797

CHICAGO, ILL. (WHITING)
123d St. & Indianapolis Blvd.
Chicago phone: Essex 5-5000
Whiting phone: Whiting 826

CINCINNATI, OHIO
1603 Carew Tower
Phone: Cherry 1-1678

CLEVELAND, OHIO
Hanna Building
1422 Euclid Avenue
Phone: Prospect 1-2175

DALLAS, TEXAS
Phone: Adams 5-5034

DETROIT 2, MICHIGAN
522 New Center Building
7430 2nd Avenue
Phone: Trinity 1-5040

EL PASO, TEXAS
1213 Mills Building
(Asarco Mercantile Co.)
Phone: 3-1852

HOUSTON 29, TEXAS
9000 Market Street Road
P.O. Box 24038
Phone: Orchard 4-7611

LOS ANGELES 23, CALIF.
4010 East 26th Street
Phone: Angelus 8-4291

MILWAUKEE 10, WIS.
4608 West Burleigh St.
Phone: Hilltop 5-7430

MINNEAPOLIS, MINN.
Phone: Tuxedo 1-4109

NEWARK, NEW JERSEY
150 St. Charles Street
Newark phone: Mitchell 3-0500
New York phone: Digby 4-9460

PHILADELPHIA 7, PENNA.
1336 Phila. Nat'l Bank Bldg.
Broad & Chestnut Sts.
Phone: Locust 7-5129

PITTSBURGH 24, PENNA.
615 Gross Street
Phone: Museum 2-2410

PORTLAND 9, OREGON
1900 N.W. 18th Avenue
Phone: Capitol 7-1404

ROCHESTER 4, NEW YORK
Triangle Building
335 East Main Street
Phone: Locust 2-5250

ST. LOUIS, MISSOURI
Mail Address: Alton, Ill.
Phone: Jackson 4-4040

SALT LAKE CITY 1, UTAH
700 Crandall Bldg.
Phone: Empire 4-3601

SAN FRANCISCO 24, CALIF.
1901 Army Street
Phone: Atwater 2-3340

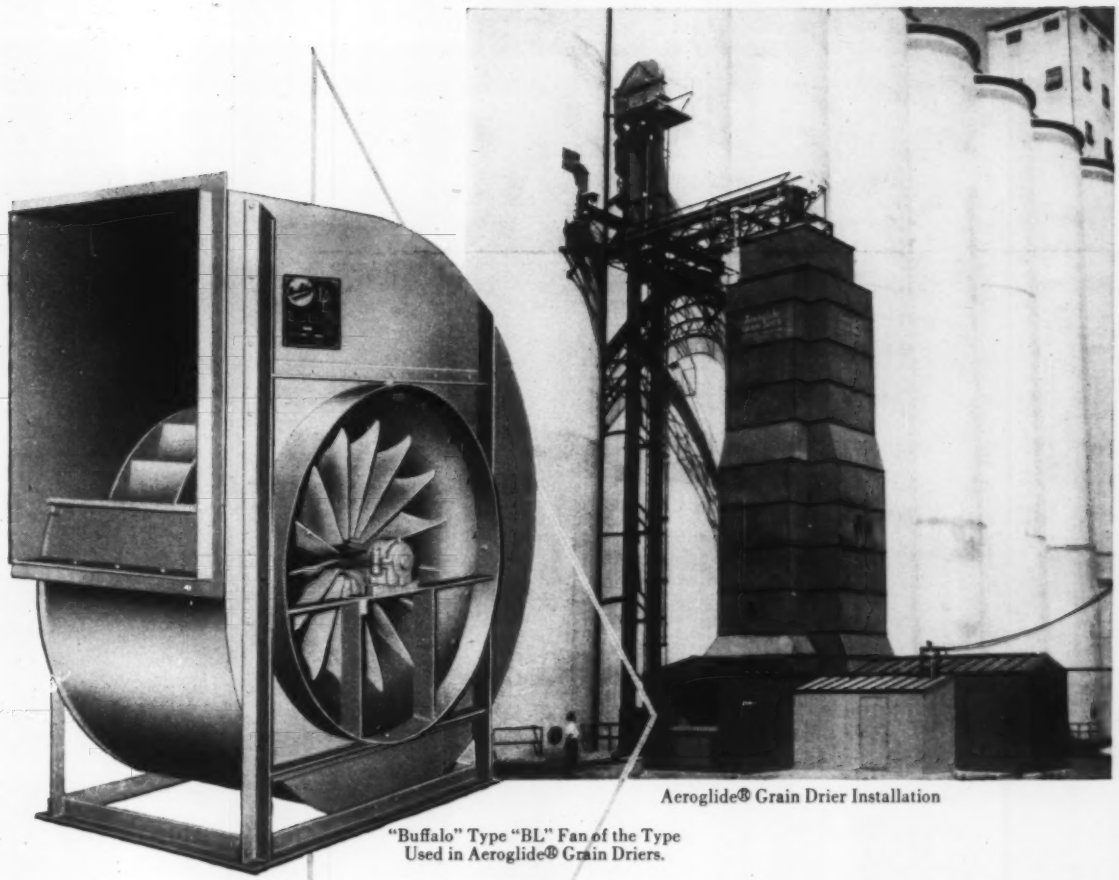
SEATTLE 4, WASHINGTON
101 Dakota Street
Phone: Main 3-7160

WHITING, IND. (CHICAGO)
123d St. & Indianapolis Blvd.
Whiting phone: Whiting 826
Chicago phone: Essex 5-5000

IN CANADA: Federated Metals Canada, Ltd.
Toronto, Ont., 1110 Birchmont Rd. Scarborough, Phone: Plymouth 7-3246
Montreal, P.Q., 1400 Norman St., Lachine, Phone: Melrose 7-3591

FEDERATED METALS DIVISION OF
American Smelting and Refining Company, 120 Broadway, New York 5, N.Y.

ASARCO



Aeroglide® Grain Drier Installation

"Buffalo" Type "BL" Fan of the Type Used in Aeroglide® Grain Driers.

WHY DESIGNERS OF AEROGLIDE® GRAIN DRIERS SELECTED 'BUFFALO' FANS

Acroglide® Grain Driers are doing an outstanding job in scores of installations throughout this country and abroad. A major feature of the Aeroglide® Drier is the induced draft principle. This has proved most economical, and results in highest quality dried grain. (Corn, oats, wheat, buckwheat, flax, barley, soybeans, lupine and milo.)

Heart of this unique drier is the fan which provides the induced draft. It is logical that Aeroglide® should specify "Buffalo" Fans for this important job. High fan efficiency is required, plus utmost dependability. The "Buffalo" Type "BL" Fans used in Aeroglide® Grain Driers are living up to their world-wide reputation for quiet, economical, reliable, efficient performance.

You can rely on this same high degree of performance and durability in *all* "Buffalo" Fans. The broad and varied line of "Buffalo" Fans of every type and size assures just the *right* fan to perform best on *your* jobs. And, at no obligation, you enjoy the services of competent, experienced "Buffalo" Engineers to help you specify the proper air moving equipment.

"Buffalo" Fans can be doing a *better* air moving job for *you*. Phone your nearest "Buffalo" engineering representative, or write direct for full information.

Every "Buffalo" Fan brings you the "Q" Factor — the built-in QUALITY which provides trouble-free satisfaction and long life.

BUFFALO FORGE COMPANY

BUFFALO, NEW YORK

Buffalo Pumps Division, Buffalo, N. Y.
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT • EXHAUSTING FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING

Circle 438 on Page 19

Circle 439 on Page 19→

Get better protection...more reliable

...WITH GENERAL ELECTRIC

operation for your product

TRI 55 CLAD ENCLOSED MOTORS

HERE'S WHY:

External Features: Moisture-resistant sealing compound is applied on carefully machined rabbets to assure better protection against moisture and dust. Corrosion-resistant, non-sparking fan on all enclosed fan-cooled Tri/Clad '55' motors resists action of the strongest acids and alkalis. Jet action cools motor effectively and efficiently for long-life operation.

Lead connections are protected from contact with moisture and dirt by a cork-neoprene gasket between halves of the easy-access conduit box.

Further, a new lead positioner gasket between conduit box and frame is impervious to cutting fluids—protects internal parts effectively.

Internal Features: Mylar* polyester film insulation and Formex† magnet wire provide greater moisture and heat-aging protection. Water-resistant stator coating also guards against failure due to moisture. And G.E.'s advanced bearing system gives years more service.

General Electric offers you the most complete line of enclosed motors in the industry, including standard enclosed, severe-duty (for highly corrosive atmospheres), and explosion-proof motors.

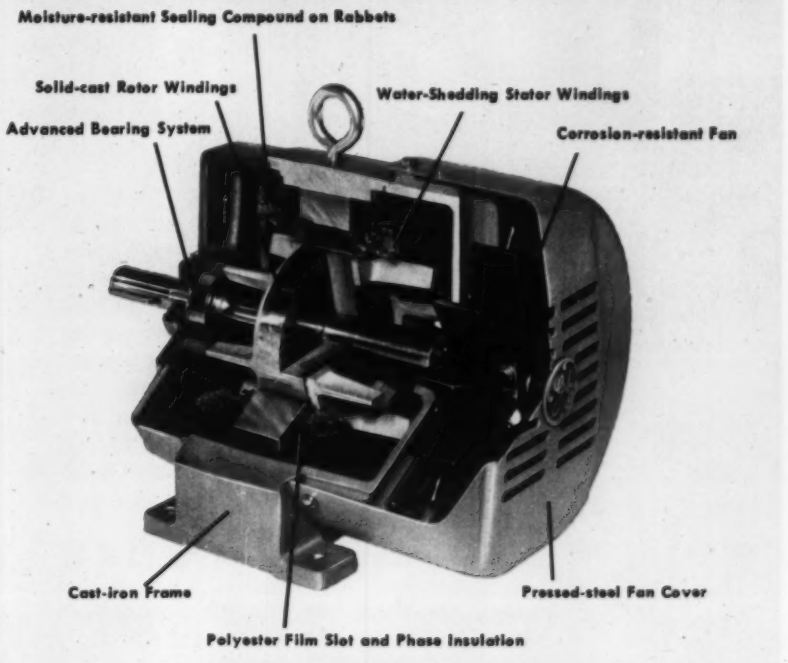
CONTACT your nearest G-E Apparatus Sales Office now for *personal proof* on why G-E Tri/Clad '55' enclosed motors can do a better job for your applications. And ask for a free copy of these descriptive motor bulletins: 1-5 hp—GEA-6240, GEA-5980, and GEA-6341; 7½-125 hp—GEA-6602. Or write for them to Section 840-20, General Electric Co., Schenectady 5, New York.

*Registered Trade-mark of DuPont Co.

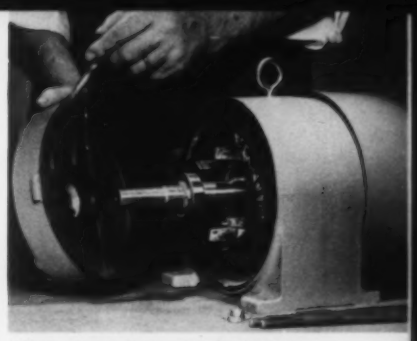
†Registered Trade-mark of General Electric Co.

GENERAL ELECTRIC

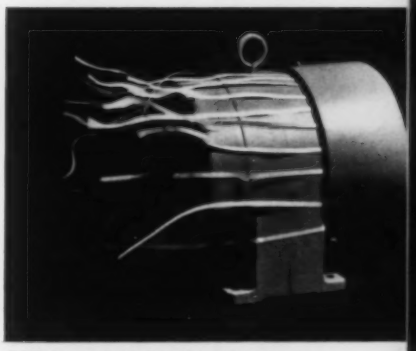
COMPARE THESE TRI 55 CLAD FEATURES



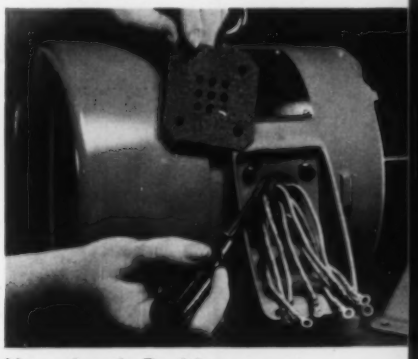
Standard enclosed Tri/Clad '55' motor



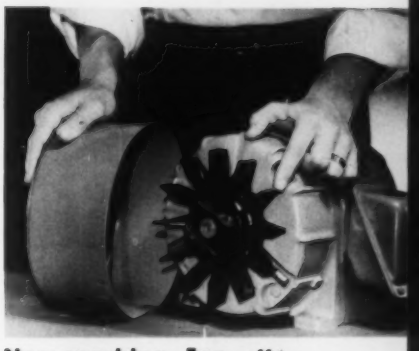
Water-resistant Rabbets protect against moisture, dirt, and abrasive dust for longer life.



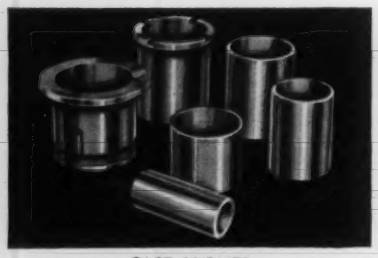
Efficient Jet Cooling System spreads a smooth blanket of air over the entire motor frame.



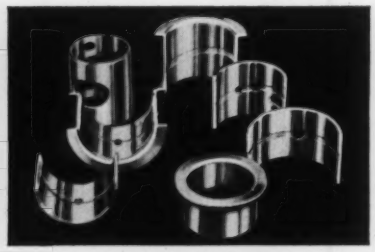
New Lead Positioner and gasket saves connection time; is impervious to cutting liquids.



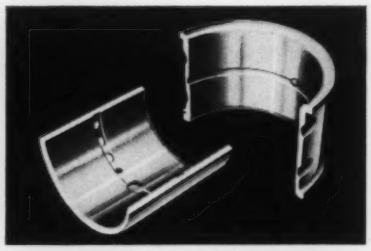
Non-sparking Fan effectively cools the motor—resists action of strongest acids and alkalis.



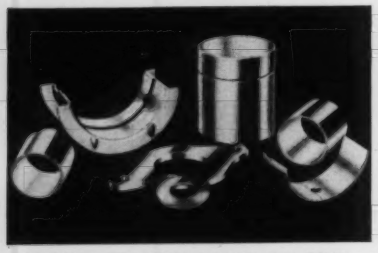
CAST BRONZE



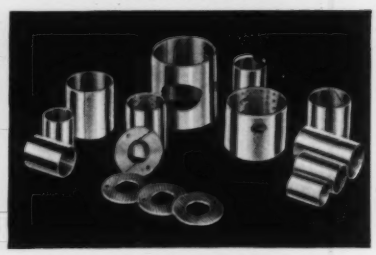
BABBITT AND STEEL



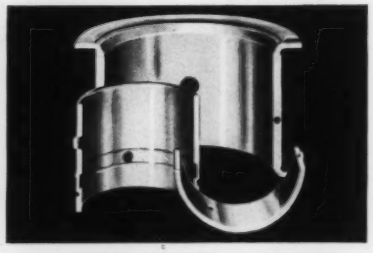
BABBITT AND BRONZE



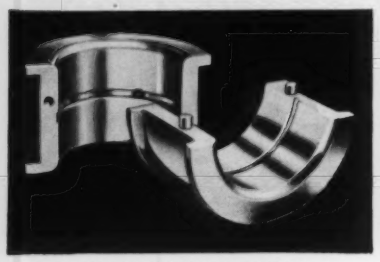
BRONZE OR COPPER-LEAD ON STEEL



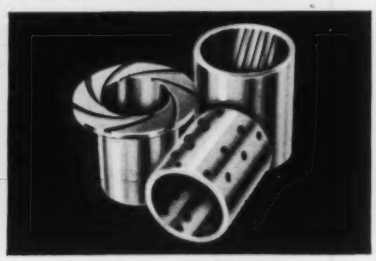
ROLLED BRONZE



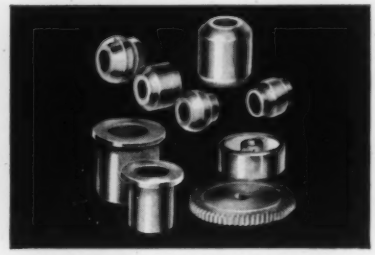
ALUMINUM ON STEEL



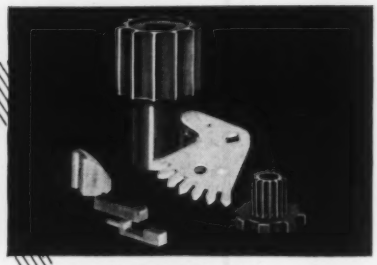
CAST ALUMINUM ALLOY



GRAPHITED BRONZE



LEDALOYL SELF-LUBRICATING



POWDERED IRON

When you need

Sleeve Bearings

Call on . . .

Johnson Bronze can provide the solution. We produce all types of sleeve bearings in a number of standard sizes. In addition, we have the facilities to produce an infinite variety of custom-made bearings to your specifications. The best bearing for any application can be found among the types illustrated above. To get the exact bearing you need at reasonable cost, contact Johnson Bronze Company, 525 S. Mill Street, New Castle, Pa.

Johnson Bronze

Subsidiary: Apex Bronze Foundry Co., Oakland, California

Circle 440 on Page 19

Circle 441 on Page 19 for Valves→

PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

Now from Parker

BOTH permanent-end

and re-usable

hose assemblies

Parker "Krimp-lok" hose assemblies — supplied in a wide variety of fittings-and-hose combinations for any type of service and fluid.

You may require permanent-end hose assemblies for your production AND re-usable fittings with coils of hose for quick, trouble-proof replacements in the field. With the addition of Parker's new "Krimp-lok" fittings, permanent-end assemblies are now available from Parker. They use the same Parker hoses that enjoy a wide acceptance when used with Parker *no-skive* "Hoze-lok" fittings in the replacement field.

A full range of Parker adapters is also available.

Ask your Parker Hose Distributor, listed in the Yellow Pages, for engineering advice and literature on "Hoze-lok" re-usable fittings, also Parker hose and adapters. Write us in Cleveland regarding your requirements for Parker "Krimp-lok" Hose Assemblies.

Parker

FITTINGS AND HOSE

DIVISION

17325 Euclid Avenue

Cleveland 12, Ohio

A DIVISION OF PARKER-HANNIFIN CORPORATION

From HANNIFIN...

unit construction

to give you air valves

that do more jobs

Hannifin ¾" four-way valve with "universal" base and new Speed Control section. Single-solenoid actuated, 10 other actuators available.

Hannifin's exclusive "spool-poppet" seals bubble-tight at either end of its short stroke.

For complete A.C. compliance, valve is electrically inoperative until dust-tight, splashproof solenoid cover is replaced and fastened tightly. Result: no more clogged, burned solenoids.

One of the versatile—and most popular—Hannifin air control valves is this "CC" series, single-solenoid model. It is available for either ¼" or ⅜" air lines and is gasket-mounted to its own base. This particular base (one of three choices offered) can either be O-ring gasketed to your manifold or mounted over an opening in your bracket or machine. It will receive all four lines from below or take the inlet line from below and the two cylinder lines out one side. Or, you can make all connections at the sides.

When it comes to actuation, Hannifin offers an even wider selection: hand, foot, cam, pressure, single or double solenoid.

When necessary, you can remove this entire valve from its base without disconnecting air lines. Or, the exclusive "spool-poppet" can be replaced without even breaking electrical connections.

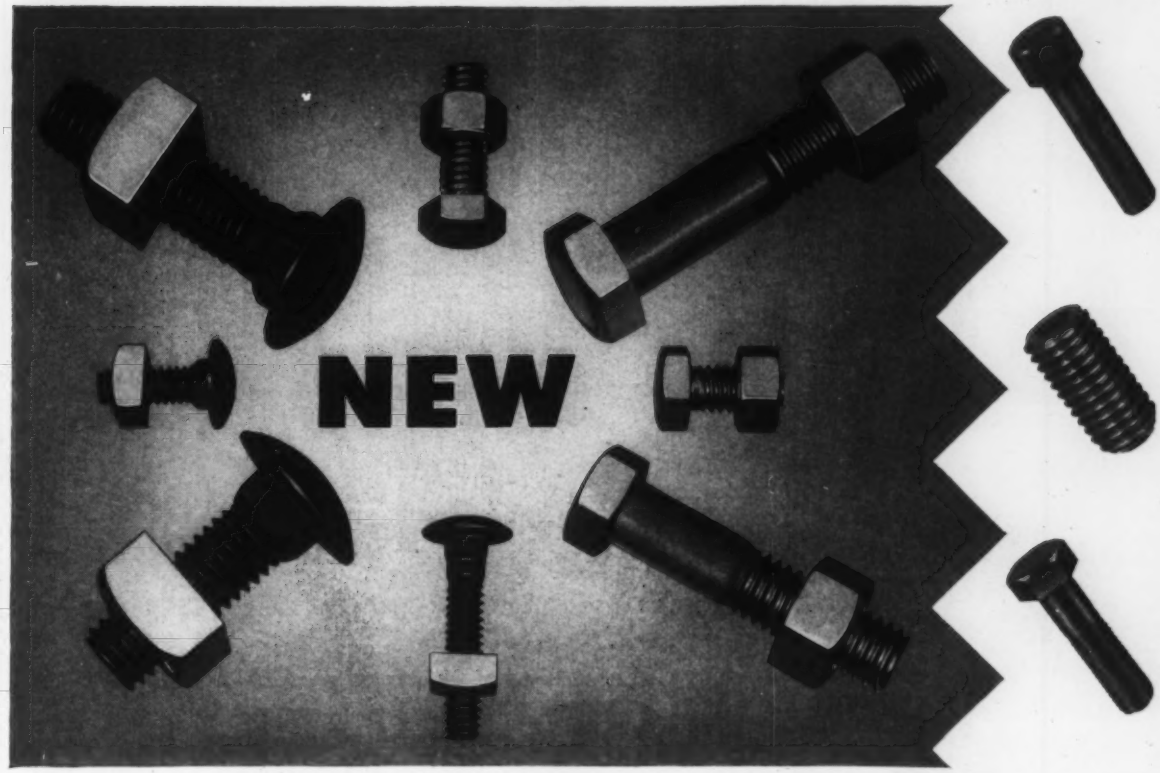
The "CC" series, like all Hannifin valves, is designed with "full flow" internal passages as large or larger than its rated pipe size.

You will find these and most other Hannifin valves described in Hannifin's new "Valve Finder." Get your copy from your Hannifin man, listed in the A-Z volume of Thomas' Register, or write:

HANNIFIN COMPANY

525 South Wolf Road • Des Plaines, Illinois

IT PAYS TO STANDARDIZE ON **STANSCREW**



Machine Bolts and Carriage Bolts Now Produced to Stanscrew Quality Standards

Stanscrew presents a new line . . . carriage and hex machine bolts . . . now produced and stocked in a complete selection of more than 500 different sizes. Manufactured under careful quality control methods, they meet the same standards of uniformity and dependability which have made other Stanscrew fasteners a leading choice of American industry for over 80 years.

These new additions bring Stanscrew's complete line to over 5,000 different types and sizes of standard, catalogued fasteners. From this comprehensive selection you can find dependable, economical answers to the overwhelming majority of all your fastener needs.

Your Stanscrew fastener specialist, available through your nearby Stanscrew distributor, can show you many ways these inexpensive standard items will cut your product costs . . . for example, by replacing costly special fasteners.

Each of the over 5,000 different Stanscrew fasteners is always kept in stock at three conveniently located plants. This enables your Stanscrew distributor to provide faster service . . . to be particularly helpful in emergency situations where prompt delivery can mean substantial savings.

So, whatever your fastener requirements, just call your nearby Stanscrew distributor. Or for complete information on Stanscrew's new carriage and machine bolts, simply mail the coupon below.

STANSCREW FASTENERS

STANDARD SCREW COMPANY

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS

HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT

WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

Standard Screw Company
2701 Washington Blvd.
Bellwood, Illinois

Please forward complete information on

☐ Machine bolts ☐ Carriage bolts

Name_____ Title_____

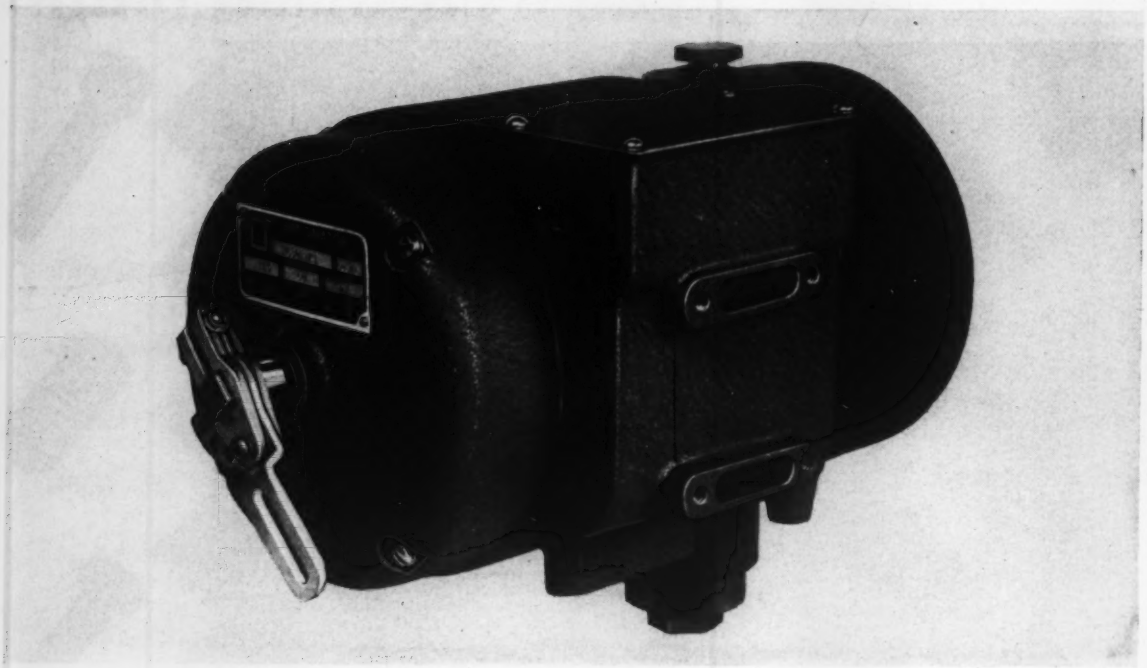
Company_____

Address_____

City_____ State_____

←Circle 442 on Page 19 for Fittings

Circle 443 on Page 19



NEW ACTIONATOR* heavy-duty electric motors operate slip stem valves

Use the powerful new ACTIONATOR industrial type motors to operate vertical acting stem valves having lifts of ½ inch through 1½ inches. Double-ended shaft can also simultaneously operate butterfly valves, rotary stem valves and other devices through suitable linkages.

ACTIONATOR motors are available with a variety of speeds, from 7.4 to 120 seconds full-stroke operation. The high speed permits use with pulse-type controllers such as those used in radiant tube firing. Torque ratings range to 200 inch/lbs.

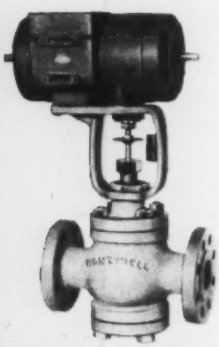
*Trademark

Other features include built-in linkage and strain relief, mounting yoke, and enclosed terminals with gasketed housing to meet JIC specifications.

Models are available with two-position, floating and proportional control. Optional models can include either one or two cam-operated, internally mounted switches for a variety of dual switching purposes. The compact assembly is self-supporting and requires no auxiliary mounting bracket. Other ACTIONATOR motors are available for use with rotary shaft type valves, dampers, louvers, or other final control elements.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.



Choose valve bodies to work with ACTIONATOR motors from Honeywell's complete line of single-seated, double-seated and three-way types.

Honeywell

H HONEYWELL *First in Control*

Circle 444 on Page 19

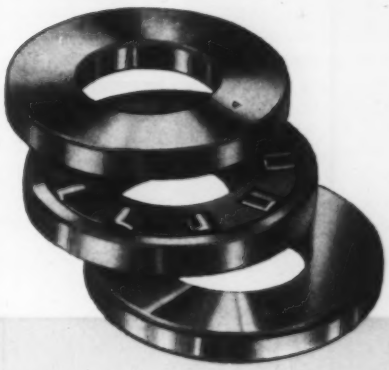
Aetna cylindrical ROLLER BEARINGS are

VERSATILE

...in assembly
...in application

Made in the two basic load carrying types of pure radial and pure thrust, they are supplied with the construction *exactly suited* to your requirements with standard, precision or super-precision tolerances in special alloys to give longer life to your products:

as complete self-contained bearings
with separable inner and outer races
with a full complement of rollers
with retainers of various types and materials



True Crowned Rollers

Each AETNA Roller Bearing incorporates rollers which are expertly ground to a fine finish with a large radius to relieve the high stress points present where two cylindrical bodies are in rolling contact and under load. The crown radius is scientifically determined and varies with the size of the roller. The result is a roller bearing which provides 10% to 15% longer service life by actual service records, because true crowning provides the best distribution of load stresses across the full length of the roller.

Call your local AETNA representative listed in the yellow pages of your Classified Telephone Book for application information, or write for General Catalog and Engineering Manual—new 15th Edition.

Aetna

AETNA BALL AND ROLLER BEARING COMPANY

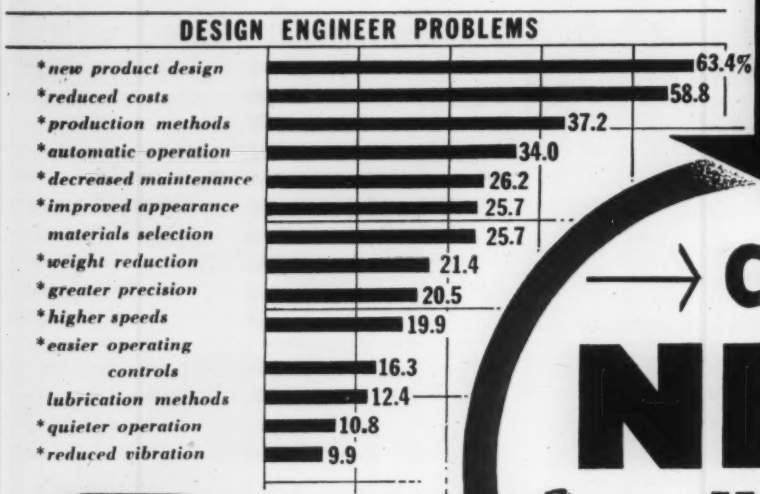
DIVISION OF PARKERSBURG-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

Circle 445 on Page 19

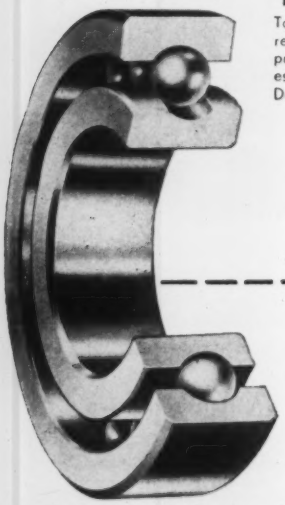
BEARING SELECTION IS AN IMPORTANT FACTOR...

in 12 Out of 14 Design Engineering Problems...

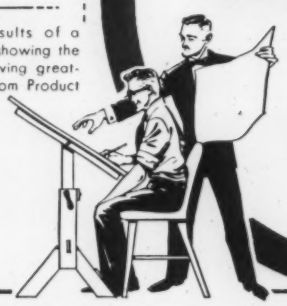


Tabulated results of a recent survey showing the problems receiving greatest attention from Product Designers.

→ Can NICE Help YOU?



As illustrated above, the new UNIBAL Ball Bearing features solid inner and outer raceways, with deep, unbroken ball grooves, PLUS a full complement of balls.



Yes, whether it be new product design, reduced costs, quieter operation or any of 12 of the 14 principal design engineering problems, the selection of bearings is a major consideration. And NICE BALL BEARING COMPANY produces complete lines of precision, semi-precision and unground standard and special bearings. Hence, NICE field and factory engineers offer the advantage of a diversified product and experience... and are well qualified to recommend or design the economically and functionally correct bearing for your particular application.

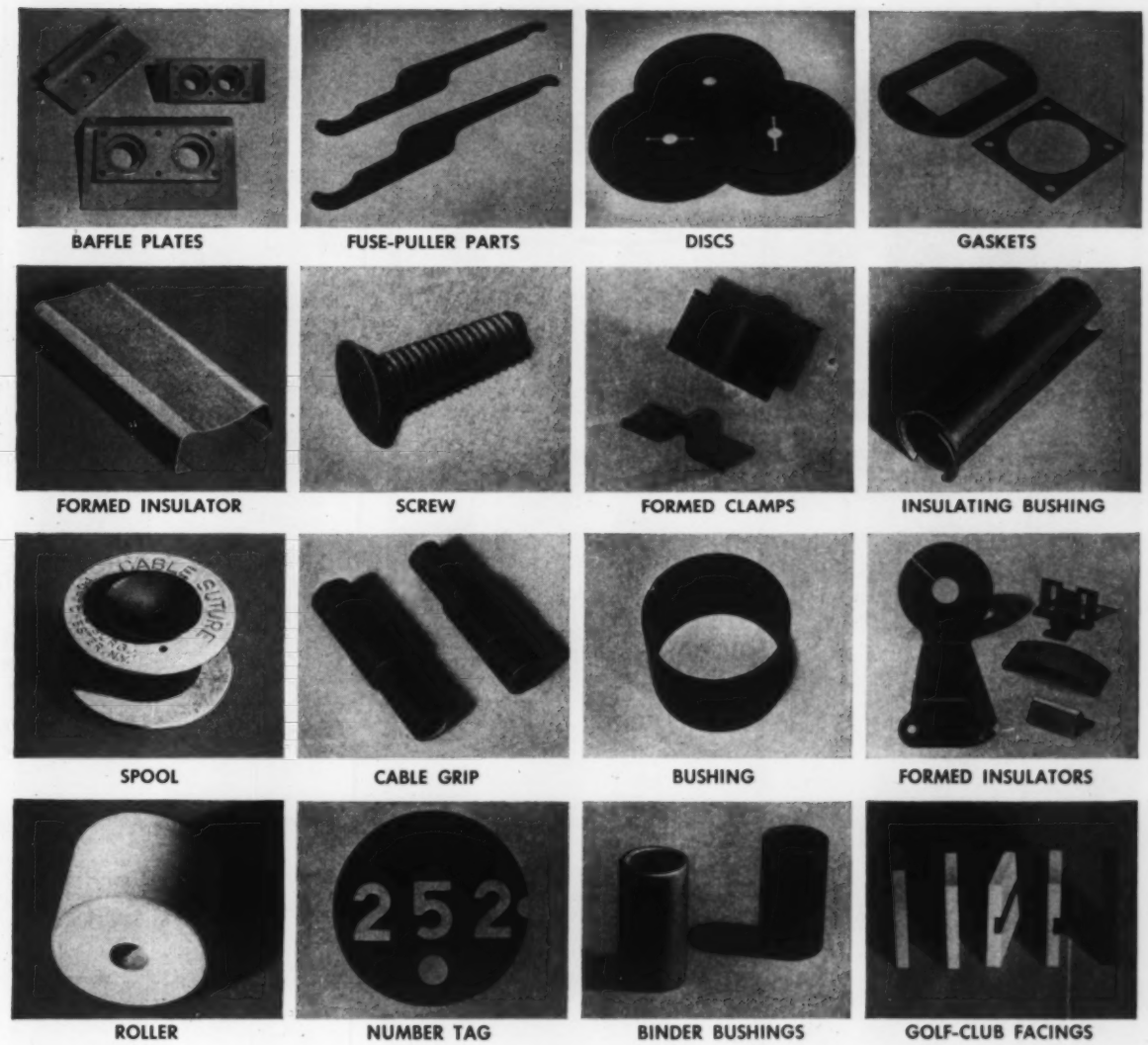
The new UNIBAL®, a NICE ball bearing of revolutionary design†, has opened up an entirely new area of savings and design improvement possibilities.

Have you investigated the design and cost saving opportunities offered by the NICE Line?

NICE®

†Patent Applied For

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA
DIVISION OF CHANNING CORPORATION



FIBRE—the low-cost insulation of 1001 uses

Look what Diamond Vulcanized Fibre can do for you! And look what *you* or CDF can do with *it!*

If you can keep high-quality fibre clear of its worst enemy—moisture—you have the best economical insulating material you'd ever want for high arc-resistance, non-tracking, and long-time dielectric strength.

UNIQUE PROPERTIES • The high tensile, flexural, and impact strengths, the easy workability (ideal for screw machines), the Rockwell hardness (to R80), the light weight (half that of aluminum), the low cost, and the excellent electrical characteristics (arc-resistance up to 150 sec.) of CDF Fibre make it a highly attractive basic insulation for cost-conscious designers and purchasing men. Put these properties to work in your product.

FABRICATION FACILITIES • CDF has excellent and extensive facilities and know-how for turning out finished Diamond Vulcanized Fibre parts—better and more economically than you can do it yourself. We meet *your* specifications and *your* production schedules, and save you time and money in the bargain.

Send us your print or your problem, and we'll return technical literature. For the phone number of the CDF sales engineer nearest you, see Sweet's, Electronics Buyers' Guide, and other directories.

CDF makes Di-Clad printed-circuit laminates, Diamond Vulcanized Fibre, CDF products of Teflon, flexible insulating tapes, Dilecto laminated plastics, Celoron molded products, Micabond mica products, Spiral Tubing, Vulcoid.

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY • NEWARK 23, DEL.

every aspect of Ward Leonard bulletin "HR" relays is designed for maximum reliability . . . these are components you can buy, install and then forget

Ward Leonard "HR" relays are engineered for industrial and electronic applications requiring: ultra-long life, high speed, high reliability, compactness and versatility.

Consider the powerful solenoids, just one of the features shown above. Every HR relay, AC or DC, is equipped with a powerful solenoid to assure fast, consistent, long-life operation so essential in the circuitry of any high reliability relay. The "E-I" laminated magnet armature is free-floating and self-aligning to minimize noise level. DC solenoids feature exceptionally fast operation. Nylon armature guides minimize operational friction. All AC and DC power plants are readily interchangeable.

2 to 8 pole "HR" relays are but one of five W/L lines of industrial power relays . . . all designed with emphasis on reliability. Write for bulletin 4470. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N.Y. 9-1

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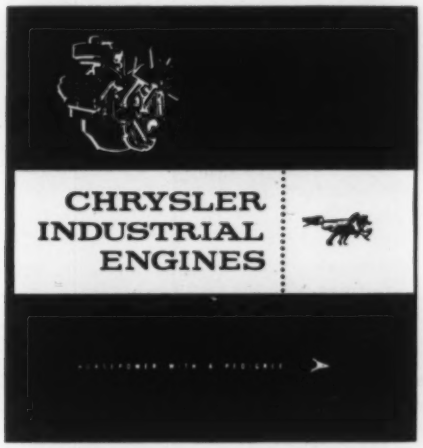
ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

LIVE BETTER...*Electrically*

Result-Engineered Controls Since 1892

RESISTORS | RHEOSTATS | RELAYS | CONTROLS | DIMMERS

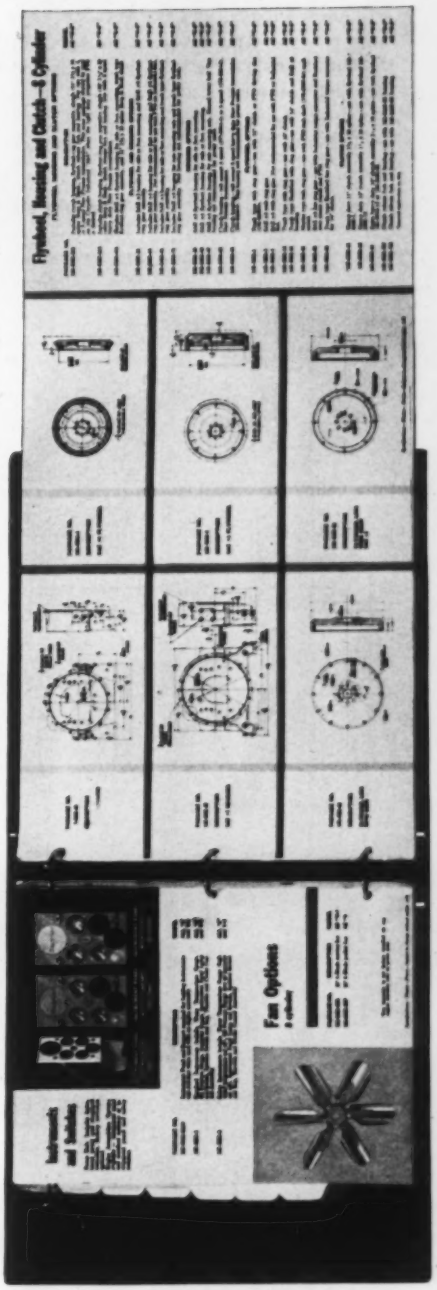
Circle 448 on Page 19



NEW CHRYSLER INDUSTRIAL ENGINE PRODUCT LINE CATALOG

helps you "build" and price an engine to fit your specific application—right at your desk.

Chrysler's new catalog gives complete details, drawings and specifications on all Chrysler Industrial Engines — 230 to 354 cu. in. displacement — plus complete details on all accessories and optional equipment. Thousands of combinations of engine, accessories and equipment are available. A simple code system helps you select and price the exact combination to fit your specific application. A call or letter will bring a Chrysler sales engineer with a copy of this catalog to "build" and price an engine *—right at your desk!*



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MARINE AND INDUSTRIAL ENGINE DIVISION
CHRYSLER CORPORATION • DETROIT 31, MICHIGAN

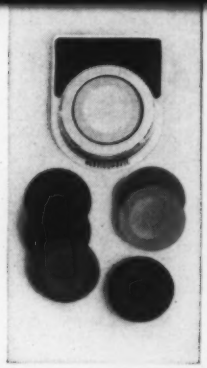
Chrysler Industrial Engines (230 to 354 cubic inch displacement) power equipment for every major industry

Air Compressors	Ditching Machines	Standby Generators	Lift Trucks	Petroleum Pumps	Shovels
Aircraft Towing Tractors	Drilling Equipment	Hydraulic Cranes	Loading Machines	Pulp Machinery	Snow Mobiles
Arc Welders	Fire Pumps	Industrial Hoists	Mobile Cranes	Road Pavers	Street Sweepers
Concrete Mixers	Farm Combines	Industrial Tractors	Motor Coaches	Road Rollers	Winches
Construction Pumps	Farm Tractors	Irrigation Pumps	Orchard Sprayers	Scoop Tractors	Yard Cranes

Circle 449 on Page 19

So what's new about a flush pushbutton? **This!** . . . new Westinghouse flush pushbuttons are the *thinnest overall!* The new button is thin . . . the new contact blocks are shallow . . . the entire flush pushbutton is the *thinnest* from front to back! What's more, you can stack these new, shallow blocks for control of multiple operations. **And this!** . . . only Westinghouse flush pushbuttons have a variety of color-coded snap-on caps that let you change the color of the button *without changing the button!* New Westinghouse flush pushbuttons are oiltite, of course . . . they were designed by Westinghouse, with the cooperation of representatives of the machine tool industry, to meet the most exacting requirements of machine tool and control panel applications.

And, they're available *now* from the manufacturer of the world's most complete line of pushbuttons. To order, simply contact your nearby Westinghouse sales office or distributor, or write: Westinghouse Electric Corp., Standard Control Division, Beaver, Pennsylvania.



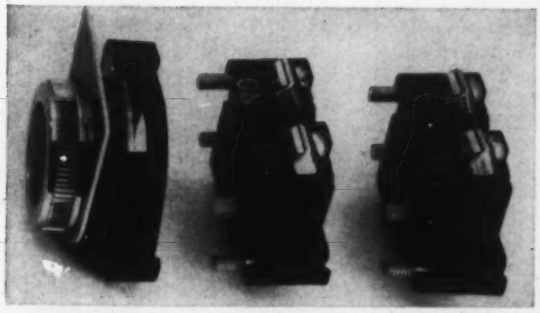
Change the color without changing the button! Color-coded snap-on caps come in red, black, blue, green, gray, yellow, brown.

YOU CAN BE SURE...IF IT'S **Westinghouse**

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

ANNOUNCING

the newest addition to

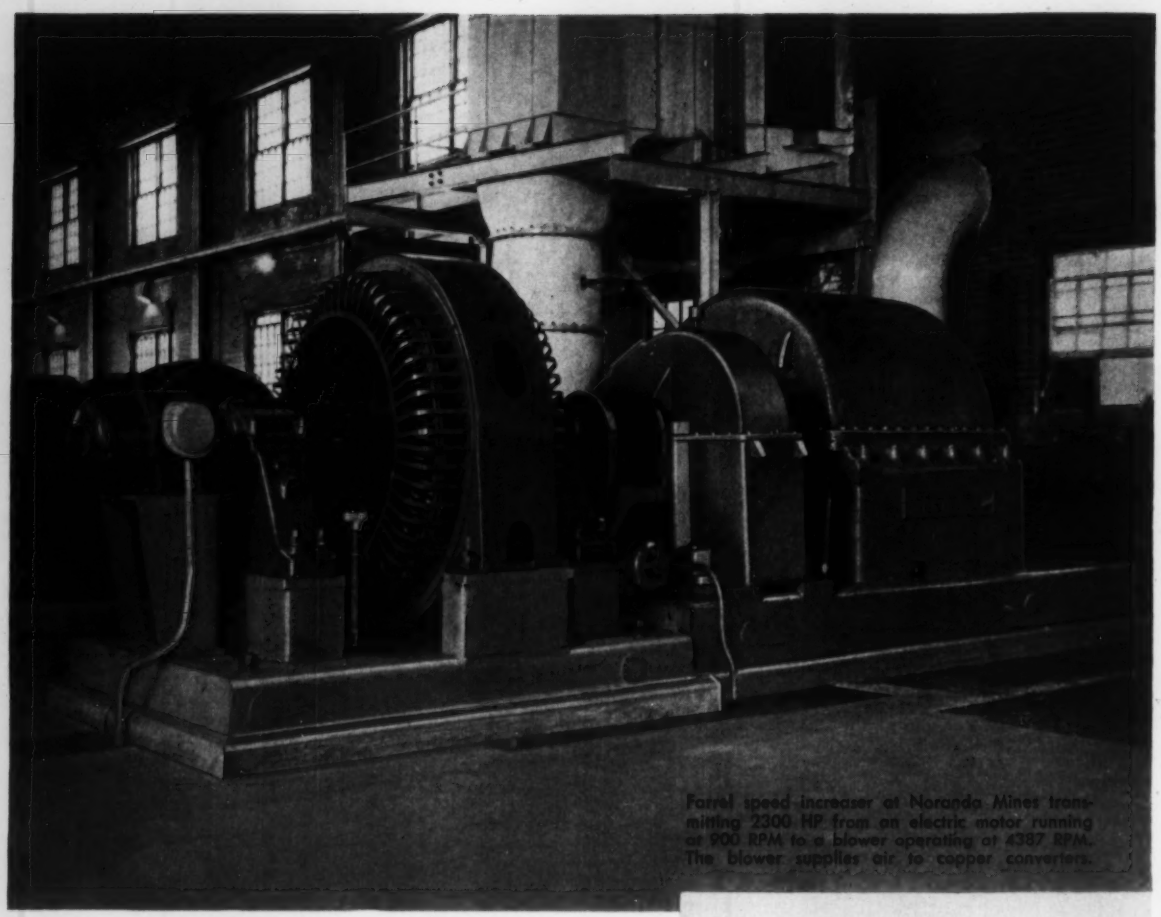


New shallow contact blocks can be easily stacked to give you multiple control circuits. Terminals are angled... easy to get at with a screwdriver, even when blocks are stacked.

industry's most complete line of pushbuttons

FLUSH PUSH-BUTTONS

Circle 419 on Page 19



Farrel speed increaser at Noranda Mines transmitting 2300 HP from an electric motor running at 900 RPM to a blower operating at 4387 RPM. The blower supplies air to copper converters.

"Both speed increasers have given us very satisfactory service"

NORANDA MINES, LTD.

These are the words of L. O. Cooper, plant engineer for Noranda Mines, Limited, Noranda, Quebec. He is referring to their two Farrel gear units, used to transmit power from electric motors to high-speed blowers.

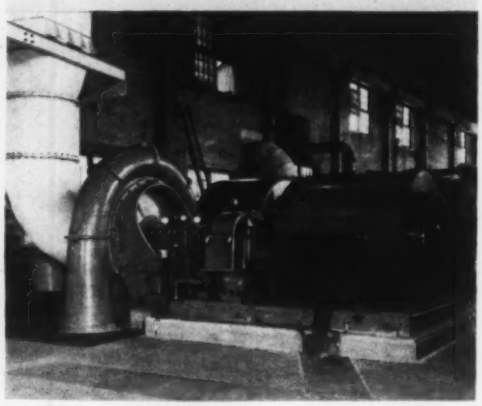
Farrel gear units have the benefits of sound engineering, skilled workmanship, high quality materials and years of experience in furnishing speed increasing units which have provided "very satisfactory" service for an indefinite period. In fact, since they were first developed in 1932, not one has ever been known to be replaced.

For full details of Farrel speed increasers, send for a copy of bulletin 451.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, Boston, Akron, Ann Arbor (Mich.), Chicago, Minneapolis, Los Angeles, Salt Lake City, Tulsa, Houston, Fayetteville (N. C.)
European Office: Piazza della Republica 32, Milano, Italy

FARREL



This 920 HP unit increases speed from 1450 to 4087 RPM. The blower furnishes secondary air to a copper reverberatory furnace.

FB-1160

Cutaway view of Federal Pacific's new circuit breaker showing TRUFLEX parts.

Federal Pacific Chooses Truflex® Thermostat Metal Assemblies for new Circuit Breaker

In designing its AB circuit breakers, Federal Pacific Electric, like more and more manufacturers, turned to General Plate for TRUFLEX Thermostat Metal Assemblies. Here's the reaction of C. A. Schmidt, Manager of Federal Pacific's Products Department:

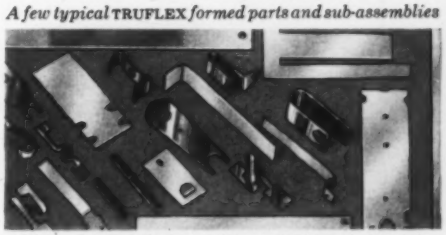
"The TRUFLEX *Thermostat Metal Assemblies in our new AB breaker equipment have more than proven their dependability and we are more than satisfied with the performance of these* TRUFLEX *components."*

General Plate manufactures these TRUFLEX Assemblies to Federal Pacific's exacting specifications and every piece is a duplicate of the original. Today General Plate makes TRUFLEX parts and assemblies for hundreds of manufacturers who have found that TRUFLEX means better control, indication and compensation of temperature in a wide range of products.

Here's why:

- **Truflex parts** and assemblies are engineered to your specifications — made with precision and uniformity, ready for installation.
- **This eliminates** the need for you to carry out prolonged experimental work and provide special manufacturing equipment. Expensive calibrating operations are not necessary when you use TRUFLEX parts.
- **If you prefer** to make your own parts, TRUFLEX metals are available in extra long coils or flat strips manufactured to exact specifications.

A few typical TRUFLEX *formed parts and sub-assemblies*



You can profit by using General Plate clad metals.

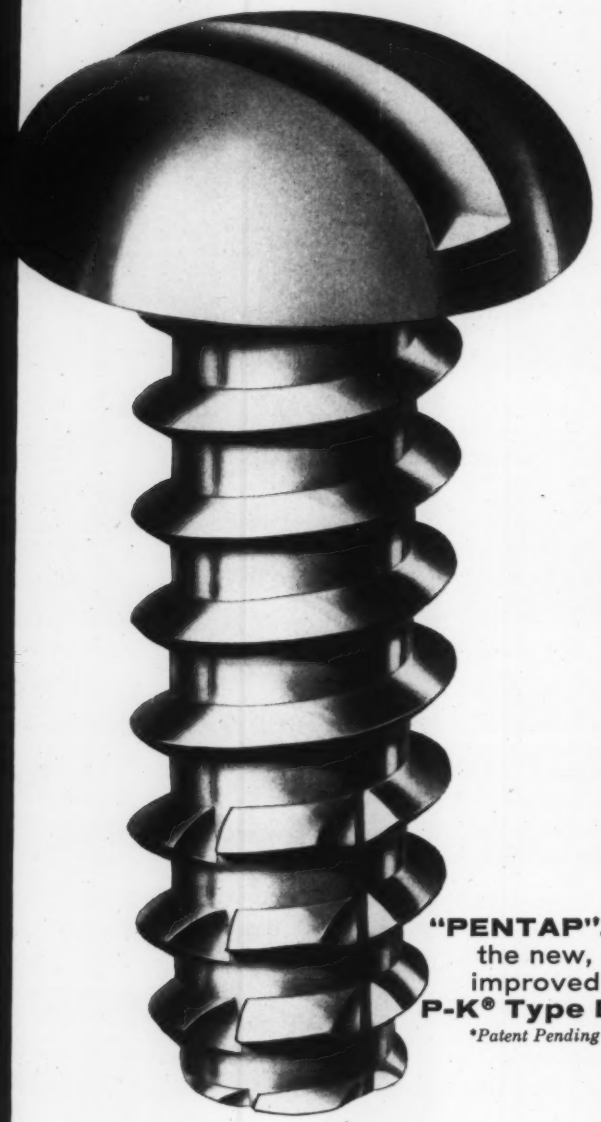
METALS & CONTROLS CORPORATION
General Plate Division
803 Forest Street, Attleboro, Mass.

FIELD OFFICES: NEW YORK • CHICAGO • DETROIT • INDIANAPOLIS • MILWAUKEE • PASADENA

Circle 452 on Page 19

Got a problem that calls for thread-cutting screws?

here are three new, improved thread-cutting screws from PARKER-KALON!



"PENTAP"... the new, improved P-K® Type B-F
**Patent Pending*

The five cutting flutes on the new, improved P-K Type "F" and "BF" reduce pressure development by 80%! The completely formed threads on these screws have sharper cutting edges, and 5 deep flutes that are of continuous depth. These features make for better clearance of the accumulated material and assure minimum stresses in driving and avoid the possibility of stripping or galling.

For Plastics

... P-K has the new improved "Pentap", Type B-F* (formerly F-Z). It combines the five thread-cutting flutes of the Type F screw with the coarse-pitch, widely-spaced threads of the P-K Type B. The new thread-cutting "Pentap" Type B-F distributes cutting pressure evenly, lets chips drop to the bottom of the hole, and prevents cracking of material. It is designed for making fastenings to comparatively thin sections and bosses in friable and brittle plastics.

The New
P-K Type L
†*U.S. Patent 2,350,346*

The New,
Improved
P-K Type F
**Patent Pending*

For Nylon

. . . Only Parker-Kalon has a completely new tapping screw, especially developed for use in this material. It's called, the P-K TYPE L†. It functions as a combination thread-cutting and thread-forming screw in that it cuts a small amount of the Nylon while allowing the full diameter threads to form. The new Type L offers a particular advantage in Nylon assemblies which must be disassembled for service because *the P-K Type L can be readily removed and replaced without stripping or galling.*

For Castings or Forgings

. . . P-K's hardened Type F** tapping screw has been developed for use in friable, granular or brittle materials such as ferrous or non-ferrous castings and bronze or brass forgings. The pilot of the P-K Type F, with its five tapping flutes, cuts a machine thread as the screw is turned in and makes a speedy, thoroughly reliable fastening.

For Structural Steel

. . . The new, improved P-K Type F** reduces driving torque in structural steels and sheet metals. By *cutting* its mating thread, the P-K Type F obtains a close fit which assures a fastening secure against loosening under vibration. The new P-K Type F has greater resistance to torque, sheer and tension loads than a machine screw in a tapped hole.

For Resin Impregnated Plywood

. . . For fastenings in these materials, the versatile P-K Type F** does the job with complete dependability. The tough, specially heat-treated Type F swiftly cuts its way into the material, grips with rugged strength, and stays tight and secure.

FOR SAMPLES OF THESE NEW IMPROVED P-K THREAD-CUTTING SCREWS contact your local *P-K "Bulk-Stocking" Distributor.* Not only is he prepared to furnish samples and full technical data, but he can supply your plant with all of its fastener requirements in production quantities, because he warehouses P-K fasteners in bulk. *Phone him for data and samples, today.*

FOR SEMS and Neoprene or Nylon washer STAPS® in thread-cutting and thread-forming tapping screws, or machine screws in every kind of pre-assembled fastener-washer combination . . . P-K can supply them all through your local "Bulk-Stocking" Distributor. *To meet the requirements and specifications of your design, Parker-Kalon offers a wide variety of types, sizes and head styles . . . THE MOST COMPLETE LINE OF PRE-ASSEMBLED FASTENER-WASHER COMBINATIONS IN THE INDUSTRY.*

PARKER-KALON®
fasteners

PARKER-KALON DIVISION, General American Transportation Corporation, Clifton, New Jersey • Offices and Warehouses in Chicago and Los Angeles.

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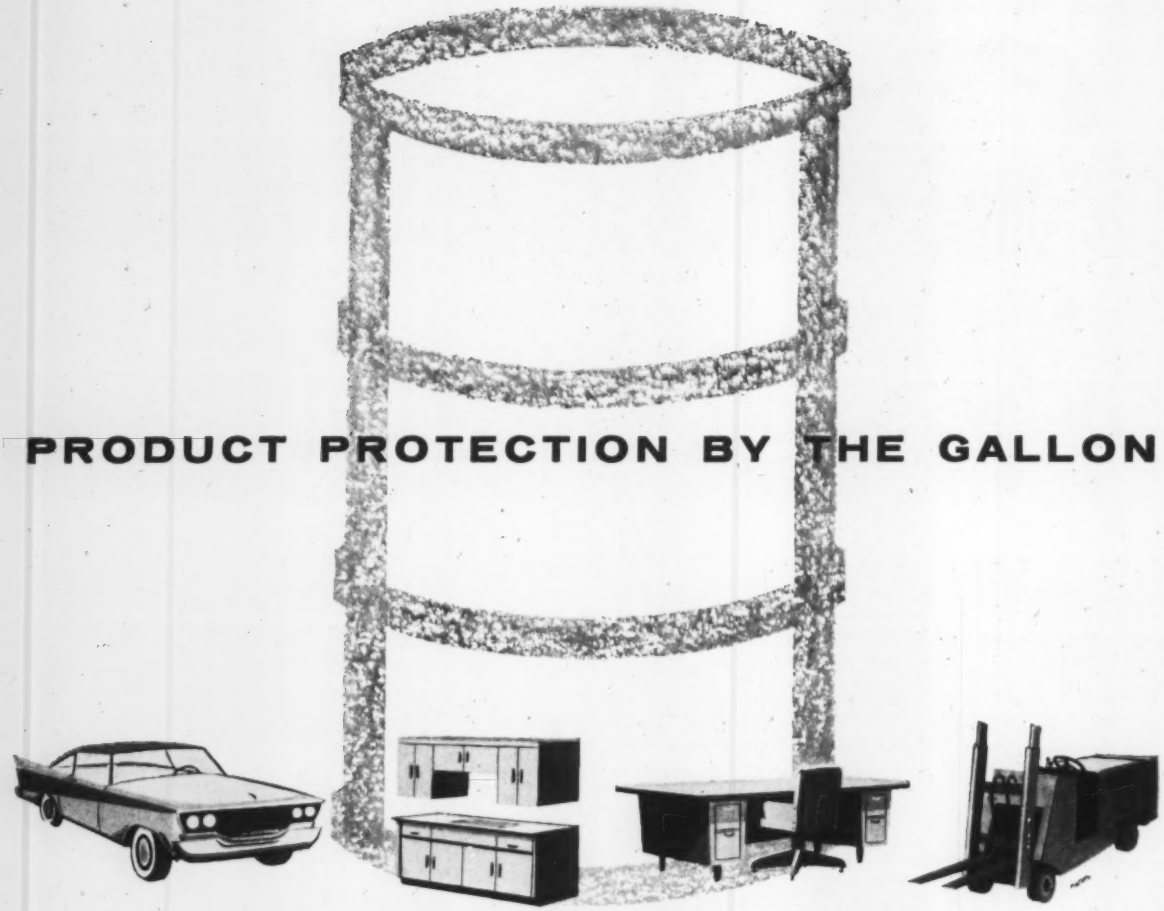


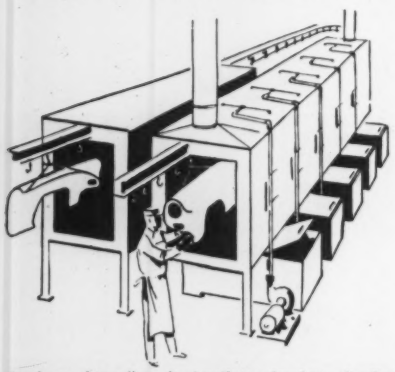
PRODUCT PROTECTION BY THE GALLON

WITH AMCHEM GRANODINE!

One of the most widely used metal finishing chemicals, Amchem Granodine is the most effective pre-paint treatment yet developed for the protection of fabricated steel products.

The non-metallic phosphate coating produced by Amchem Granodine provides an effective base for durable paint finishing and greatly improves the corrosion resistance of the finished product. A variety of Granodizing processes are available for a wide range of finishing operations . . . to assure your products of greater usability through lasting protection.

It may be well worth your while to investigate cost saving, efficient Amchem Granodine—today's most modern metal finishing chemical for steel. Check Amchem where service goes beyond the product with a complete program of technical and engineering assistance!



Granodizing process may be applied by power spray (shown on left), dip system or by hand application.

Write for Bulletin 1380 with Selection Chart to help you choose the Granodine type for your specific needs—and bulletins featuring other Amchem chemicals of vital interest to the fabricator of steel products.

AMCHEM GRANODINE

Amchem Granodine is another chemical development of **Amchem Products, Inc.**, Ambler, Pa. Formerly American Chemical Paint Company, Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont./Amchem and Granodine are registered trademarks of Amchem Products, Inc.

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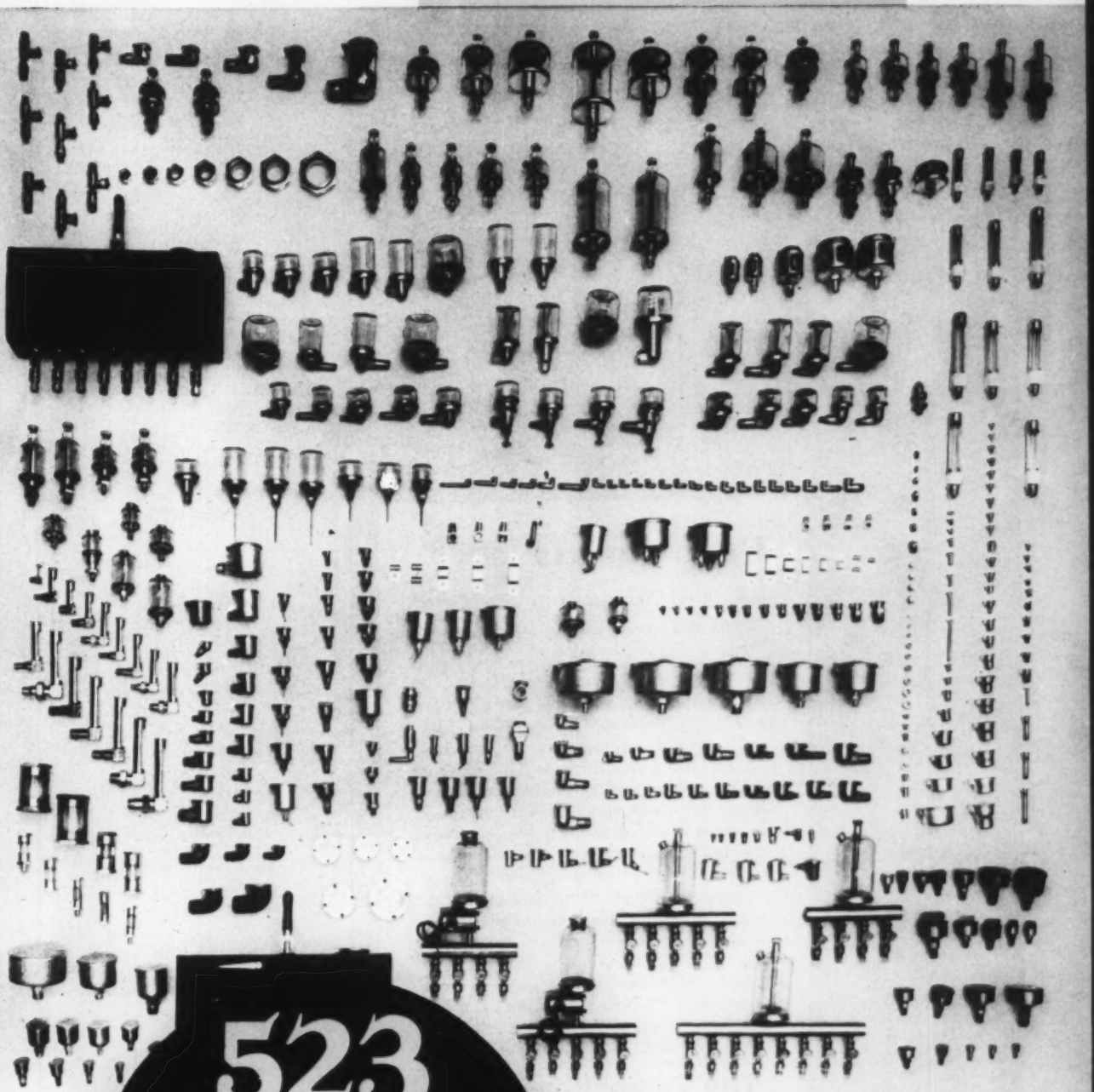


523 GITS OILERS AND GAUGES READY TO SHIP

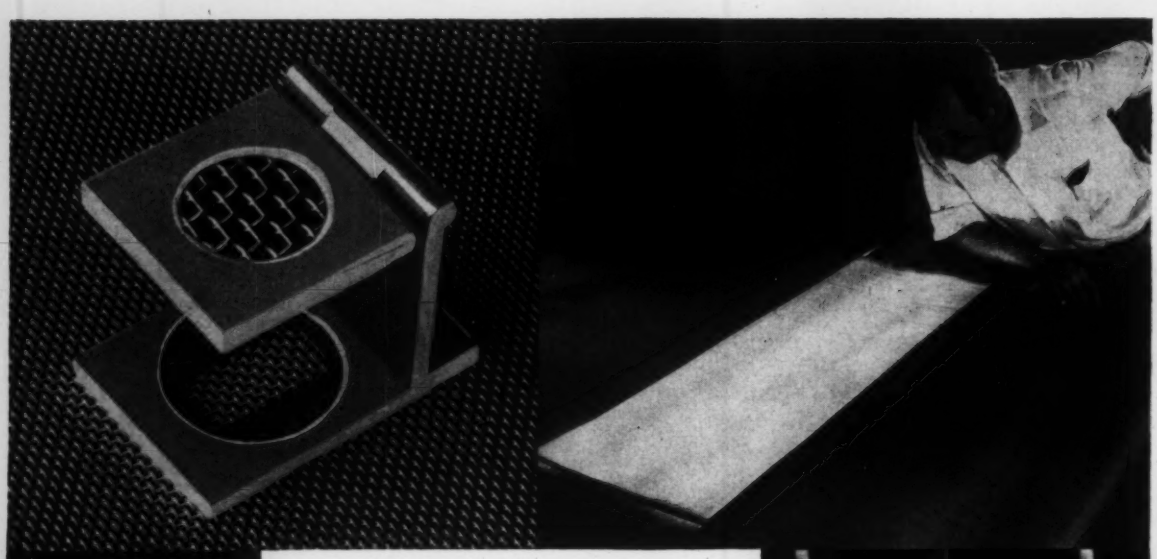
Largest selection available anywhere. You save time and money, because the one you want is always right in stock. Send for complete Catalog.

Specialists in Lubricating Devices and Shaft Seals for Almost Half-A-Century

GITS BROS. MFG. CO.

1868C S. Kilbourn Ave., Chicago 23, Ill.

Circle 455 on Page 19

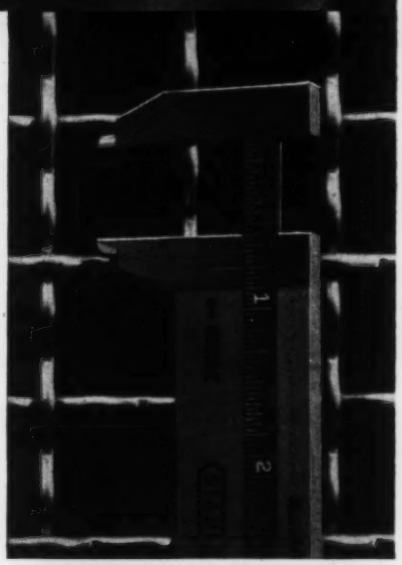


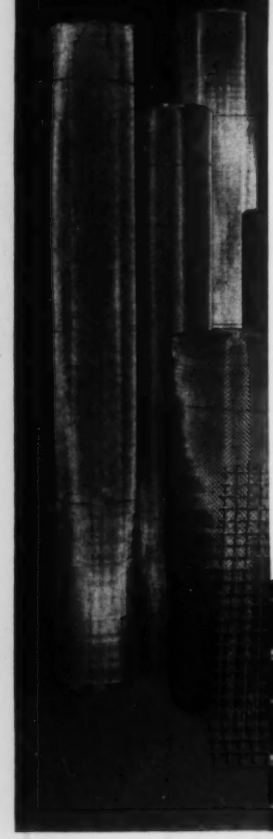
Who counts 'em?

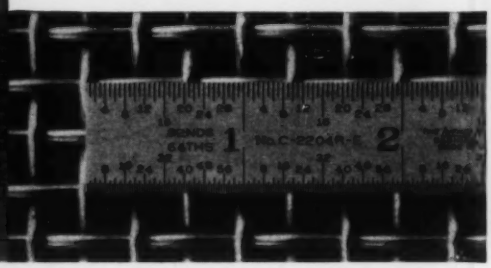
CAMBRIDGE does . . .

. . . because *exact* mesh count and mesh size are the trademarks of Cambridge INDUSTRIAL WIRE CLOTH.

But, quality isn't the whole story. When you call Cambridge for industrial wire cloth, you also get service . . . prompt answers to your inquiries . . . quicker deliveries . . . and an experienced Field Representative who follows up your order to make sure our product is giving you the best possible service. Let us quote on your wire cloth needs. We manufacture wire cloth from any metal or alloy—including titanium—in nine basic weaves. Very likely, we have what you require in our warehouse right now. For samples or more information, call your Cambridge Field Engineer...he's listed in the yellow pages under "Wire Cloth". Or, write for FREE 94-PAGE CATALOG.







The Cambridge Wire Cloth Co.

Department N • Cambridge 3, Md.

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

Circle 456 on Page 19

Circle 457 on Page 19→

How GENERAL STEEL CASTINGS

can improve product

design and performance

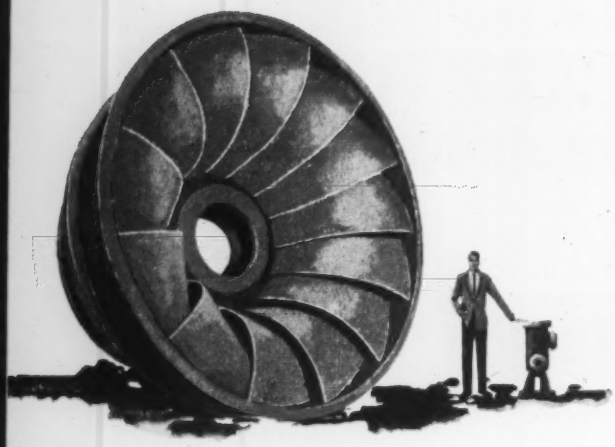
The demands of progress in today's industrial economy impose exacting new operating and service standards upon "capital goods" machinery and equipment. To build into their products the stamina necessary to meet these requirements, more and more manufacturers are taking advantage of the superior properties inherent in steel castings.

The great freedom of metal distribution possible in steel castings results in a maximum strength-to-weight ratio, compactness, flexibility of design details, high shock resistance, and long service life. The full advantages steel castings have to offer in your product, however, can be gained only through the experienced application of a wide range of services.

General Steel has pioneered for more than 50 years in providing to industry a complete service, ranging from design through production, for cast steel structures and steel castings used in cast-weld and composite structures. Today the company serves a wide variety of industries in the United States and many foreign countries. Now, with a continuing expansion program, General Steel offers this complete service to additional manufacturers who seek to keep pace with industrial progress by increasing the value, performance, and engineering economies in their products.

where industrial progress is cast in steel....

NOW...take advantage of this complete service to meet your specialized requirements



From concept to casting, General Steel offers a complete service . . . a unique blending of research and development, creative design, quality production, and follow-through in the field.

In two strategically located plants General Steel has the space, facilities and staffs to plan, develop and engineer structures to meet your specialized requirements. We are equipped to work from your specifications . . . or simply with "raw ideas". We prefer to work with you from the start, for it is in this kind of teamwork that our skills most successfully complement your own.

General Steel's Granite City Plant in the St. Louis Industrial Area includes 127 acres, 37 of which are under roof, and has a capacity of about 4000 tons of finished castings monthly.

General Steel's Eddystone Plant in the Philadelphia Industrial Area includes 112 acres with 20 under roof, and has a monthly capacity of approximately 3000 tons of finished industrial castings.

Circle 457 on Page 19

Application Analysis.....

Sales, Engineering, and Manufacturing personnel evaluate your products' structural requirements and work with you to determine the most advantageous applications of steel castings.

Design Engineering.....

Creative teamwork between your staff and our engineers brings many specialized talents together to develop optimum structural design.

Metallurgical Service.....

Experienced staffs and fully equipped laboratories provide up-to-date metallurgical counsel in addition to close manufacturing control of materials.

Production Facilities.....

Two plant areas, exclusive of our National Roll and Foundry Division, have experienced personnel and complete facilities for producing machined castings ranging in size from 100 pounds to 100 tons.

Non-destructive Testing.

Radiographic, magnetic particle and ultrasonic inspection equipment together with specialized personnel assure compliance with the most exacting quality standards.

Field Service.....

Follow-through in the field by specialized personnel from all departments of the company insures that all structural performance requirements are met.

LET US CONSULT WITH YOU ON YOUR PRESENT PRODUCTS ...AND FUTURE PROJECTS. CALL US IN NOW.

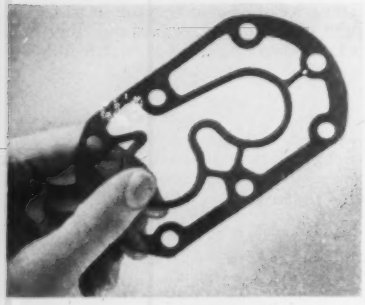
GENERAL STEEL CASTINGS

GRANITE CITY, ILL. • EDDYSTONE, PA. • AVONMORE, PA.

Technical data for gasket design and selection

Choosing a gasket for compressors

In selecting a gasket material for a compressor head, the first consideration is the gasket's ability to withstand the usual ambient temperature of about 300° F.



At such elevated temperatures, and with internal pressures ranging well over 100 psi, torque retention becomes another critical factor.

In the case of refrigerator compressors, the choice of a gasket is further limited by the presence of refrigerant gases which attack many materials.

A material that meets these requirements is Accopac AN-890, a new beater-saturated gasket material pioneered by Armstrong. Accopac AN-890 is a blend of refined asbestos fibers with a nitrile-type rubber binder.

AN-890 withstands temperatures up to 800° F. Its nitrile-type rubber binder swells slightly in the presence of refrigerant gases. Since these gases do not deteriorate AN-890, the swelling acts to maintain a tight seal.

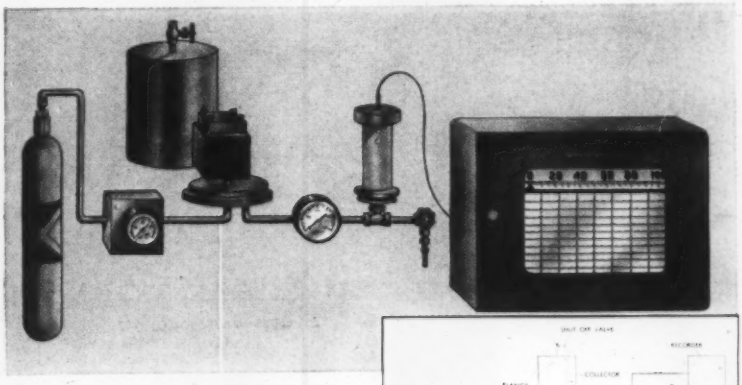
Bolt torque retention of Accopac AN-890 has been proved by comparing a flange containing refrigerant gas at 350° F. and 150 psi, and a control flange at room temperature and no gas. Accopac maintained bolt torque equally well in both flanges.

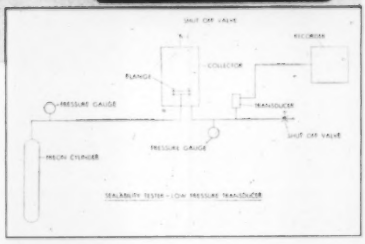
Send for a copy of the new Armstrong Gasket Design Manual. Write on your business letterhead to Armstrong Cork Company, 7103 Dean Street, Lancaster, Pennsylvania.

Testing the sealing characteristics of refrigeration compressor gaskets

Sealing a refrigerator compressor can be a tough gasket problem. The effects of elevated temperature and high internal pressure are aggravated by the tendency of refrigerants to attack some gasket materials.

In developing an improved gasket for compressors, Armstrong research engineers tested commercially available materials. They found that none of these provided a gas-tight seal. In order to test the behavior of these materials—as well as the performance of Armstrong compounds under development—it was necessary to know how much leakage was involved and the effect of time on the leakage rate.





The apparatus shown here provides such information. FREON* refrigerant under 128 psi at 72° F. is piped to a gasketed compressor flange covered by a sealed collector. Leakage is sensed by a transducer as an increase in pressure in the collector. The increases are continuously recorded.

With this apparatus, the effect on gasket materials of such gases as FREON refrigerant can be observed and evaluated. As one example, it is known that this gas has a pronounced swelling effect on unconfined samples of gasket materials that contain nitrile-type rubber. In this device, however, materials are tested under normal compression, and tests show that the swelling effect of the FREON improves the sealing efficiency of the gasket.

As a result of such testing, Armstrong has developed a new high-density asbestos gasket material—Accopac AN-890. This new product seals better than some conventional materials, and it offers a cost saving of from 15% to 30%.

At Armstrong, research on problems of gasket design, selection, and performance is a full-time activity. This work may be of help in solving a sealing problem for you. We'll be glad to make suggestions if you send details to us.

*FREON AND COMBINATIONS OF FREON- AND F- WITH NUMERALS ARE REGISTERED TRADE-MARKS OF THE E. I. DU PONT DE NEMOURS & CO., INC., FOR ITS FLUORINATED HYDROCARBON REFRIGERANTS.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

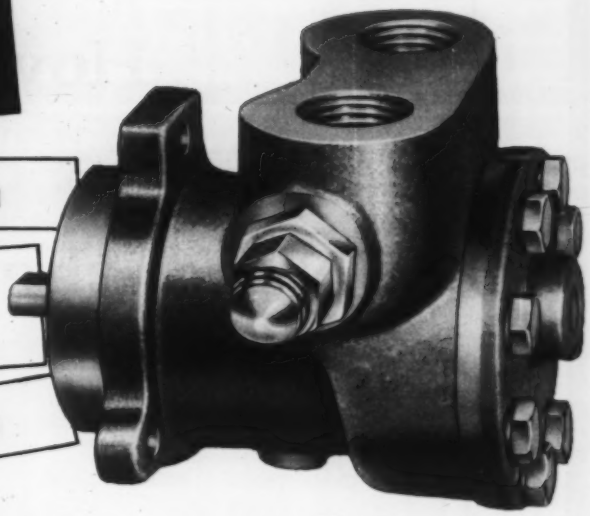
Circle 640 on Page 19

NOW

Compact design

Complete mounting interchangeability

Built-in relief valves



on TUTHILL small industrial pumps

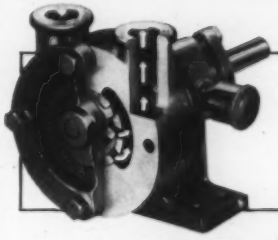
Now a new design—Series LPFV—gives you even greater flexibility with Tuthill small industrial pumps . . . the industry standard for dependable operation for many years.

Complete interchangeability allows the use of any one of five different sizes in the series on the same mounting arrangement. Capacities range from 20 to 360 gallons per hour, at pressures up to 500 psi. Normally provided for 1800 RPM, 3600 RPM speeds are permissible in most cases. And a built-in relief valve is now offered as optional equipment on all LPF models.

Compactness, an outstanding characteristic of all Tuthill pumps, is particularly exemplified in the new model LPFV with its shorter mounting hub. It is also available in close coupled motor-pump combinations for applications where space and weight are at a premium.

The newly designed model LPFV incorporates the performance-tested operating characteristics of Tuthill's internal gear construction described at right. In thousands of applications . . . in hydraulics, lubricating, transfer, circulating and other services . . . Tuthill internal gear pumps have established enviable records for reliability and quiet operation.

Over 700 models of Tuthill internal gear pumps are available to provide one especially suited to your application. These include stripped models for built-in applications, cartridge pumps, reversible models . . . a host of specialized pumps for each individual service. Mail the coupon today.



TUTHILL internal gear pumping principle

In Tuthill internal gear pumps, proven in 30 years of operation, there are only two moving parts. The principle is based upon the use of a rotor, idler gear and a crescent shape partition cast integral with the cover. Power applied to the rotor is transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the outside diameter of the rotor is sealed by the crescent. As the pump starts the teeth come out of mesh increasing the volume. This creates a partial vacuum drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and the rotor and is carried past the crescent partition to the pressure side of the pump. When the teeth mesh on the pressure side the liquid is forced from the spaces and out through the discharge port.

Tuthill Pump Company
951 East 95th Street
Chicago 19, Illinois

☐ Please forward information on LPF series
☐ Please have your representative call

Name_____ Title_____

Company_____

Address_____

City_____ State_____

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GPM; for Pressures to 1500 PSI; speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

How to help your customers COUNTrol their production

Do your customers complain of spotty production . . . short-runs, over-runs, uncertain quality control, uneven performance from your machine or product? If so, there's one thing you can do about it . . . build a Veeder-Root Counter into your product as a standard integral part. Then you can offer your customers constant visual *Count*rol of your product's performance . . . which amounts to recorded proof of your product's guarantee.

You'll find, too, that built-in counters build up sales. And you can count on us to "teach your product to count". Write.

You always "Know the score" when you count on Veeder-Root!

NEW "VISICOUNTER"

Gives greater figure-visibility with dome-shaped window. Better suited for panel mounting. This rugged, heavy duty counter comes in both ratchet and geared types. 6 non-overthrow wheels. 1-piece case.

Everyone can Count on

Veeder-Root Inc.

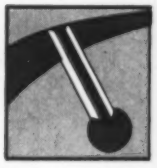
HARTFORD 2, CONNECTICUT

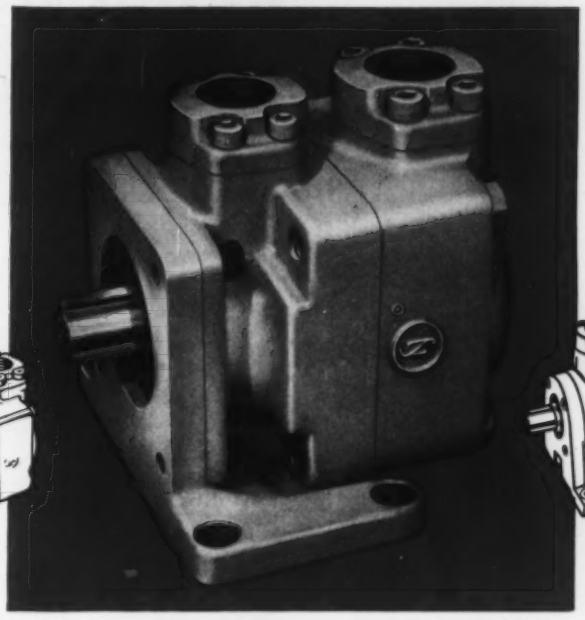
Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

Circle 459 on Page 19

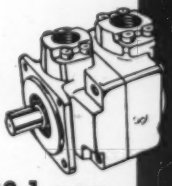
HYDRECO® Announces—

TWO NEW SERIES OF DUAL-VANE PUMPS FOR 2000 PSI CONTINUOUS OR INTERMITTENT OPERATION

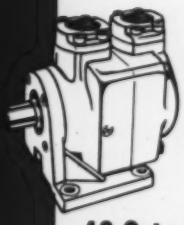




PF-200



14.5 to 38.1 gpm
at 1200 rpm-0 psi



PF-300

43.0 to 72.5 gpm
at 1200 rpm-0 psi

CHECK THESE FEATURES

The greater efficiency and economy of 2000 psi *single stage* operation.

•

Dual-Vane construction—the proven principle of hydraulic balance—higher mechanical and volumetric efficiency.

•

Improved design of cam ring provides greatly increased cam life.

•

Two sizes give complete range of capacities from 14.5 to 72.5 gpm . . . PF-300—300 Double Pumps give capacities to 144 gpm.

•

Cartridge construction . . . Pump rotation can be changed by merely reversing cartridge.

•

Housing ports can be rotated to any position 90° to each other.

Member NFPA

NFPA NATIONAL FLUID POWER ASSOCIATION

Design engineers, seeking Vane Pumps that deliver substantial improvement in performance, longer service life and higher over-all efficiency will find much of interest in these HYDRECO Dual-Vane Pumps. Whether the application imposes the exacting performance of automated production machinery or hydraulic presses, these HYDRECO Dual-Vane Pumps possess the long-sought extras.

For continuous or intermittent 2000 psi operation, these Pumps are outstanding. Within the capacity range of 14.5 to 144 gpm obvious applications include: Injection Molding, Die Casting, Hydraulic Presses, Scrap Balers and Metal Working Machinery. There are many other areas wherein the advanced design and high performance features of HYDRECO Dual-Vane Type Pumps will excite special interest. Write for full information today.

Write

for Bulletin 10420.1 and performance data

HYDRECO DIVISION
THE NEW YORK AIR BRAKE COMPANY
9006-3 EAST MICHIGAN • KALAMAZOO • MICH.

Please send me Bulletin 10420.1 and performance curves on Series PF-200 and PF-300 HYDRECO Dual Vane Hydraulic Pumps.

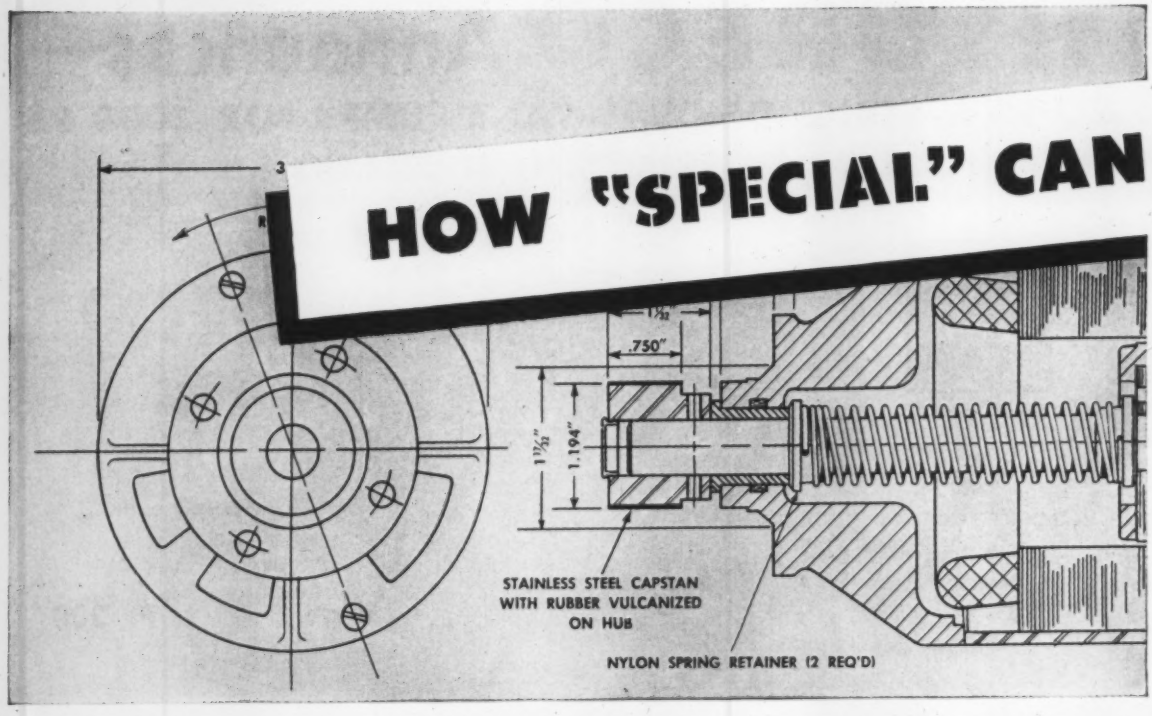
Name_____

Company_____

Address_____

City_____ Zone_____ State_____

Circle 460 on Page 19

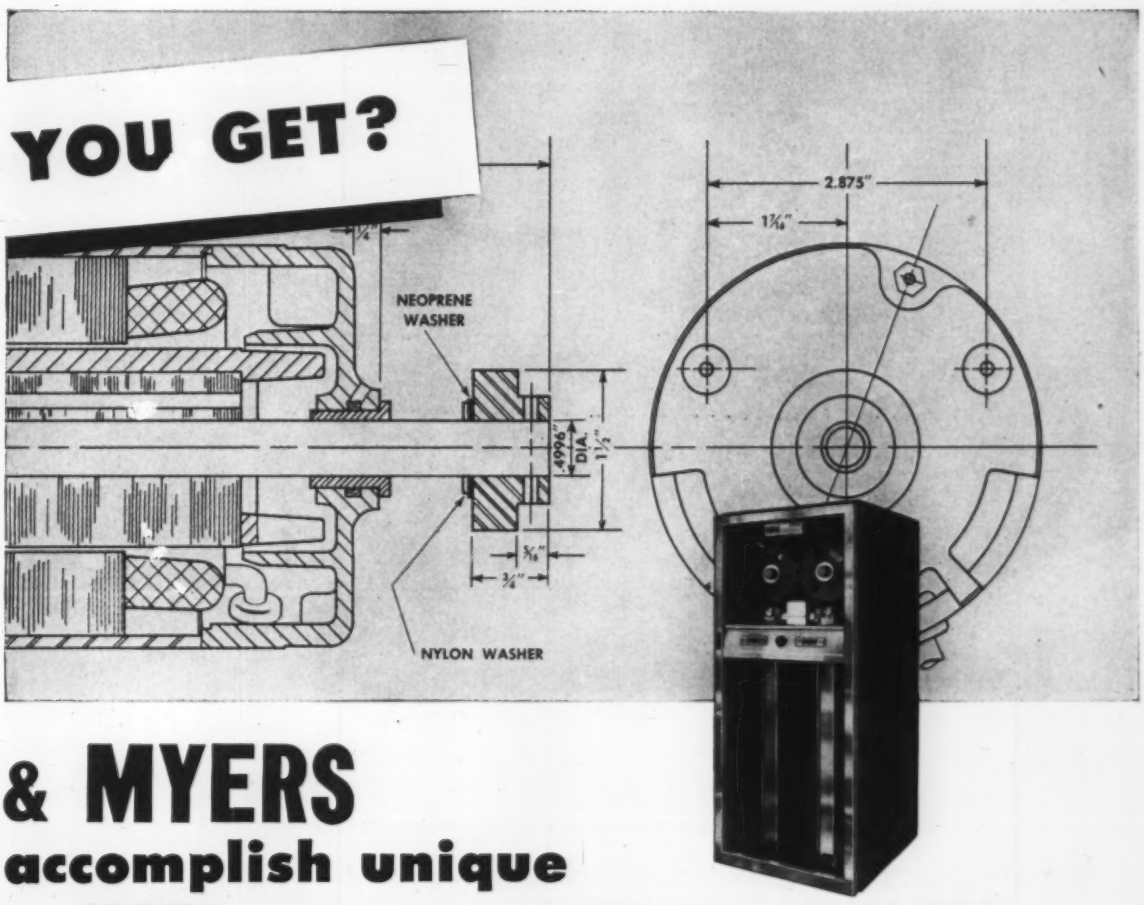


SPECIAL ROBBINS capstan motors function

SPECIFICATIONS

Reluctance synchronous motor, 1/20 HP, 60 cycle, 3 phase, 208 volts ± 8%, 1200 RPM . . . Rotor dynamically balanced to commercial specifications . . . Shaft is shown in position when motor is stopped . . . When motor is running at synchronous speed, a minimum axial force of 350 grams is required with spring in place before displacement occurs . . . When rotor is in its retracted position and power is applied, the minimum axial force developed with spring in place is 100 grams . . . When power is cut off, the spring retracts the rotor with minimum 50 gram force while rotor is rotating.

Robbins & Myers builds motors from 1/200 to 200 horsepower



& MYERS
accomplish unique in IBM'S 727 magnetic tape unit!

SHAFT ROTATES AND MOVES AXIALLY

Two of these special R&M motors are used in each of IBM's 727 Magnetic Tape Units. They answer IBM's need for a tape unit drive motor with a retractable capstan. The rotating shaft moves axially when the motor is started or stopped.

A spring holds the rotor, shaft and capstan in retracted position when the motor is stopped. When started, as the motor attains synchronous speed, axial force created as the rotor centers itself in the field becomes sufficient to overcome spring resistance. The capstan moves into engaged position and sends the tape reels rolling. Another capstan on the opposite end of the shaft (at right in drawing) actuates two microswitches as the rotor returns to retracted position when motor is stopped.

Four additional R&M fractional horsepower motors perform other high-speed power tasks within the tape units —driving reels, rewinding, unloading tape and retracting guide mechanisms.

R&M motors meet strict IBM engineering requirements: precise adaptability to special functions, capacity for lightning starts and stops, and absolute dependability. R&M can also design and build motors of highest quality designed to your exact specifications. For reliable fractional power, contact Robbins & Myers!

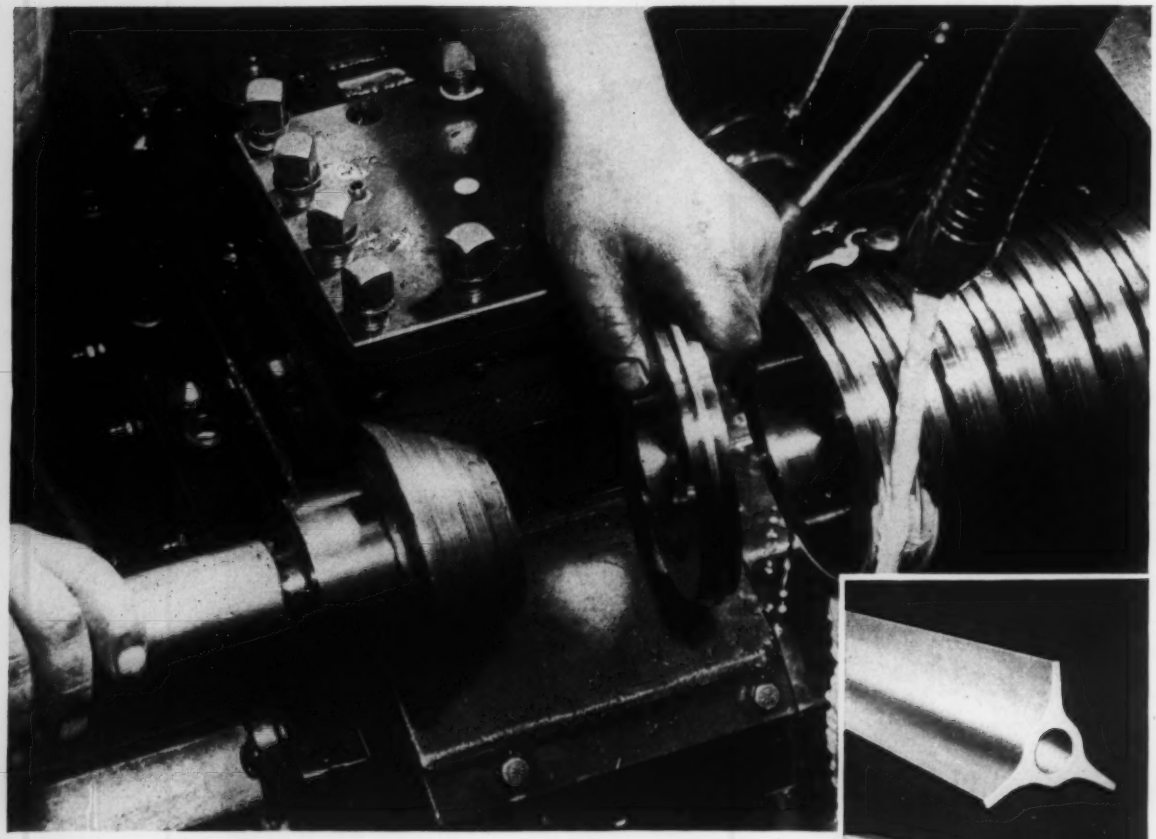
R&M

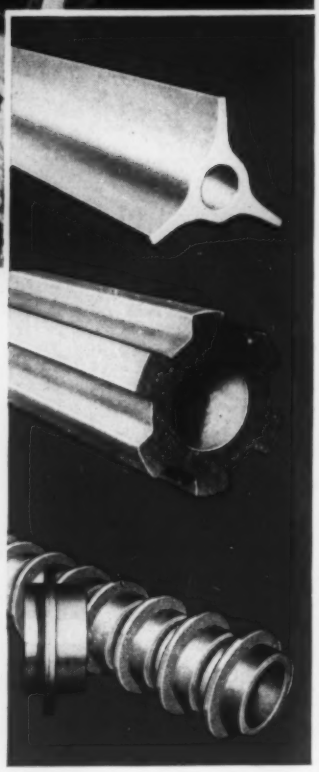
ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

MOTORS FANS HOISTS MOYNO PUMPS PROPELLAIR FANS

Circle 461 on Page 19





ESCO CUSTOM CONTOURED SPUNCAST CUTS MACHINING COSTS

If you are machining steel parts that are hollow, tubular or symmetrical in shape, you can effect real production savings with *ESCO* Spuncast.®

Spuncast, a centrifugal casting process, can produce your parts blanks with a *built in hole*. Because the hole is already there, there is little machining to do, less metal to buy. Contours can also be "tailored" for minimum stock removal. *ESCO* Spuncast offers further opportunities to cut machining costs. Your Spuncast parts can be cast in a "multiple parts stick". Instead of chucking up one part at a time, you can make one set-up and machine many parts. Thus, parts are produced faster and set-up time is sharply reduced.

ESCO Spuncast is available in 95 steel alloys, in a wide range of wall thicknesses, lengths and in special shapes and can be heat treated to your specifications. Small quantity orders can be economically produced.

Ask your nearest ESCO representative for your free 12-page brochure . . . "How to Cut Costs With ESCO Spuncast", or write direct.

ESCO®

ELECTRIC STEEL FOUNDRY COMPANY

2183 N. W. 25TH AVE. • PORTLAND 10, OREGON
MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.
Offices in Most Principal Cities
ESCO INTERNATIONAL, NEW YORK, N. Y.
IN CANADA ESCO LIMITED

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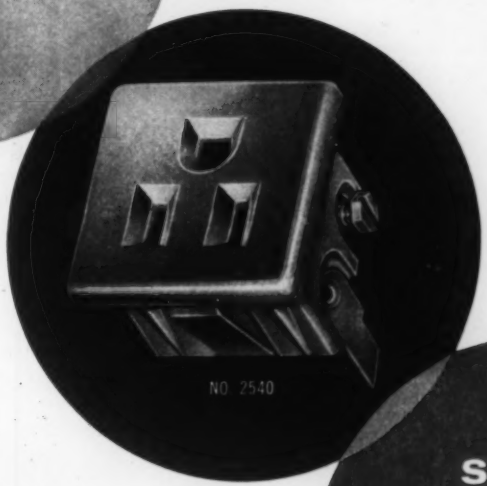
CIRCLE F



choice of
screw terminals
male tabs
wire leads
absolute ground

wherever the power supply must be grounded . . .

it's grounded best with Circle F's SNAP-IN U-GROUND CONVENIENCE OUTLET— listed both by UL and CSA. Specified for use on ranges, "power blocks," and many other applications, it has an all-bakelite body, double wiping contacts, a 15 Amp.-125 Volt rating and is available in grey, brown, black, and white. When you specify Circle F, you get precision-engineered devices of "custom-made" grade. Circle F's fast, quality-controlled manufacture takes less time *and guarantees lowest cost!*

SNAP-IN U-GROUND CONVENIENCE OUTLET

APPLIANCE SWITCH
NO. 2230

CONVENIENCE OUTLET
NO. 340

CONVENIENCE OUTLET
NO. M438

PILOT LIGHT
NO. 490

MALE LOAD PLUG
NO. 344

keep your costs on the ground by specifying Circle F's quality-controlled snap-in devices. a model for every use.

CIRCLE F MFG. CO.

TRENTON 4, NEW JERSEY • For your wire requirements: Eastern Insulated Wire Corp., Box 591, Trenton, N. J.

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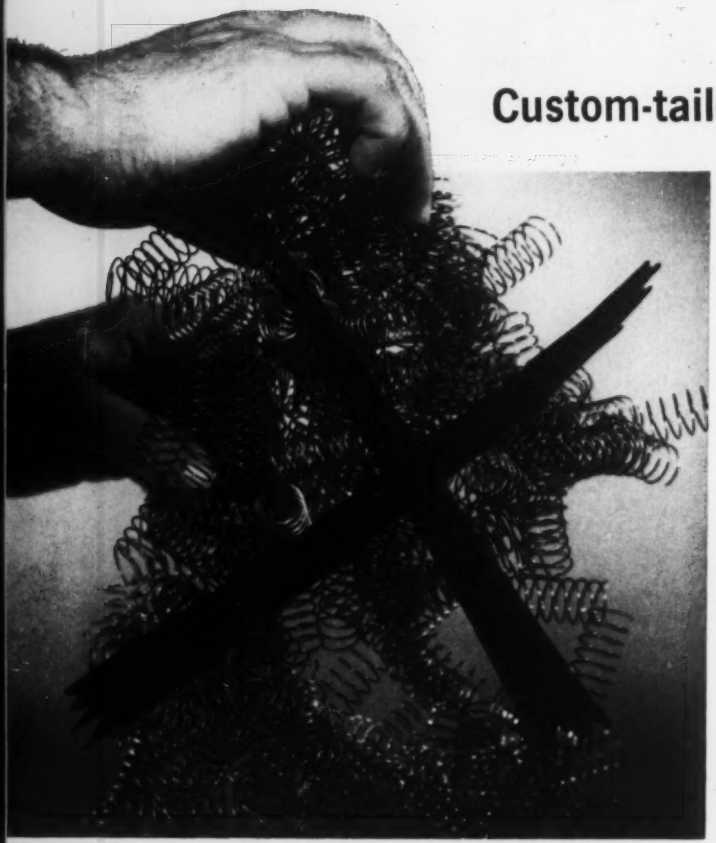
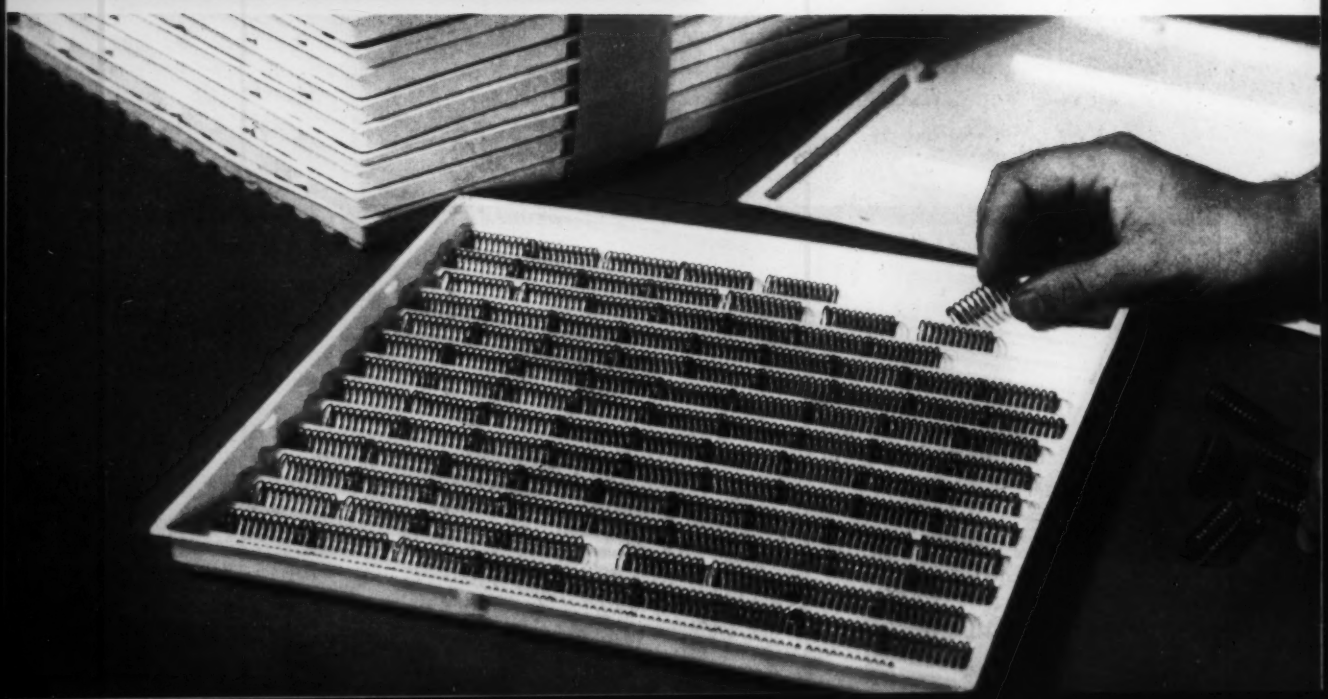
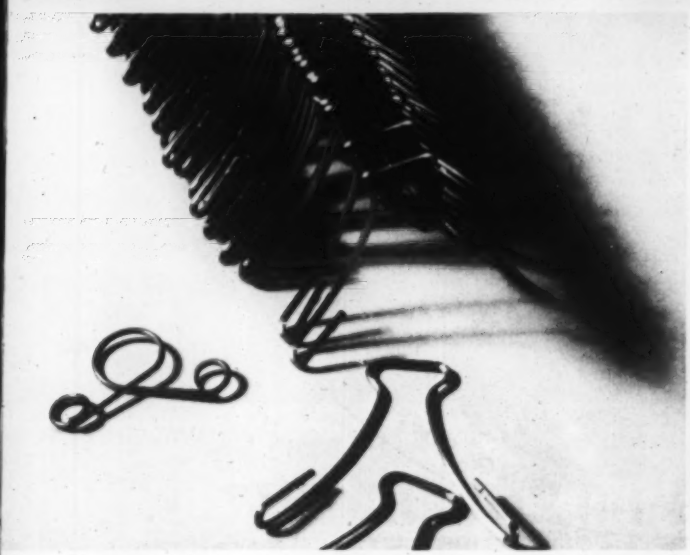
NEW... Spring Flow®



Custom-tailored packaging of springs that cuts costs and speeds operations in your plant

Spring Flow is a systematic approach to the problems of handling and storage of springs, wire forms, small stampings, in customer plants. It overcomes time-wasting tangling, and the distortion that often results from tangling. It can be engineered for specific applications to expedite hand or automatic assembly.





Spring Flow lowers handling and assembly costs — eliminates distortion — protects finish

Spring Flow makes use of a variety of modern materials, dispensers, containers. The extent to which it may be applied depends on the complexity of each individual part and handling requirements. The cost of Spring Flow is frequently offset by resulting savings.

The potential benefits of Spring Flow almost defy imagination. Ask for a Spring Flow proposal for your springs or other fabricated-metal products. Or find out more about this exclusive service by writing for the new booklet—"Spring Flow."

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
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Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

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5908

Tubexperience in action

How does carbon content control hydraulic tubing quality?

Precise metallurgical controls help Superior's (SAE) Hydraulic Tubing outperform all other types

*Extra quality is the reason for the high ductility and longer, more reliable service you get with Superior hydraulic tubing. This extra quality is actually built in through precise metallurgical control.

Carbon content is held to .12% maximum through controlled atmosphere annealing. This assures highest ductility commensurate with the strength needed in the tubing.

Superior (SAE) Hydraulic Tubing is made from selected billets of non-aging steel. These are segregated by heat numbers, and a customer's order is always filled from one heat. This assures complete uniformity of all the tubing shipped to him in that order.

Each order also undergoes many critical examinations. Among these are checks on elongation, yield and ultimate strength. Every length is also 100% hydrostatically tested to maximum working pressure. And close control is exercised over grain size and microstructure. This is done microscopically with the aid of metallographic mounts. And finally, if requested, we furnish a notarized report on the chemical and physical properties of the tubing produced.

Superior (SAE) Hydraulic Tubing is furnished in dead-soft annealed temper for easy bending and flaring. Order in cut, multiple or random straight lengths up to 30 ft.—or longer in coiled form.

For more data on our (SAE) hydraulic tubing, get a free copy of Bulletin 39. Write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

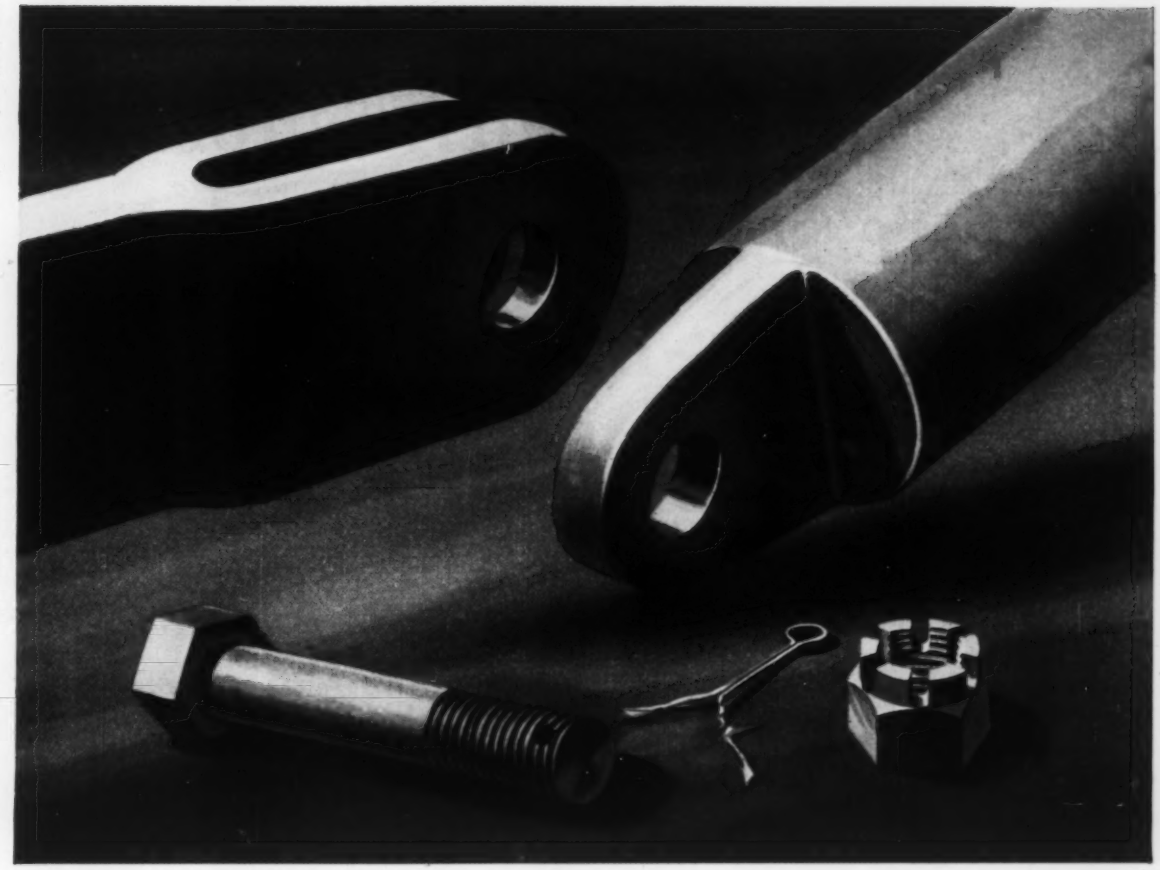
Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331



The case of

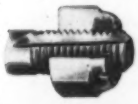
THE ALMOST PERFECT DESIGN

This is a closeup of an equipment failure. Somewhere in the basic design, someone forgot to specify a nut that would hold fast. Now the entire piece of equipment is idle. Does it matter how good the overall design is?

The most brilliant engineering concept can be obscured or cancelled out by the failure of components. In the final analysis, then, a design which does not include fail-safe performance for the benefit of the user—and the protection of the maker—is inefficient and uneconomical. In the eyes of the customer, a failure of the smallest part is failure of the unit.

For bolted connections, it is possible to obtain "design insurance"... an extra margin of operating dependability that can mean the difference between satisfaction and a field breakdown . . . by specifying an Elastic Stop® nut with the failure-proof red nylon locking insert. The nylon insert will not destroy bolt threads or finishes; it is non-galling; it will withstand severest vibration, shock and impact loads; and it can be re-used over fifty times on a bolt of standard quality.

ESNA offers a broad line of standard and thin height hex nuts, and a size range from 0-80 to 3". Also many special configurations to solve your unusual design problems. For detailed information and photos showing how the designs of some of America's foremost manufacturers of heavy equipment have utilized Elastic Stop nuts for critical bolted connections . . . write to Dept. S32-34, Elastic Stop Nut Corporation, 2330 Vauxhall Road, Union, New Jersey.



DOUBLE DEPENDABILITY

The dependability built into every Elastic Stop nut builds itself into the dependability of every product on which it is used.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA

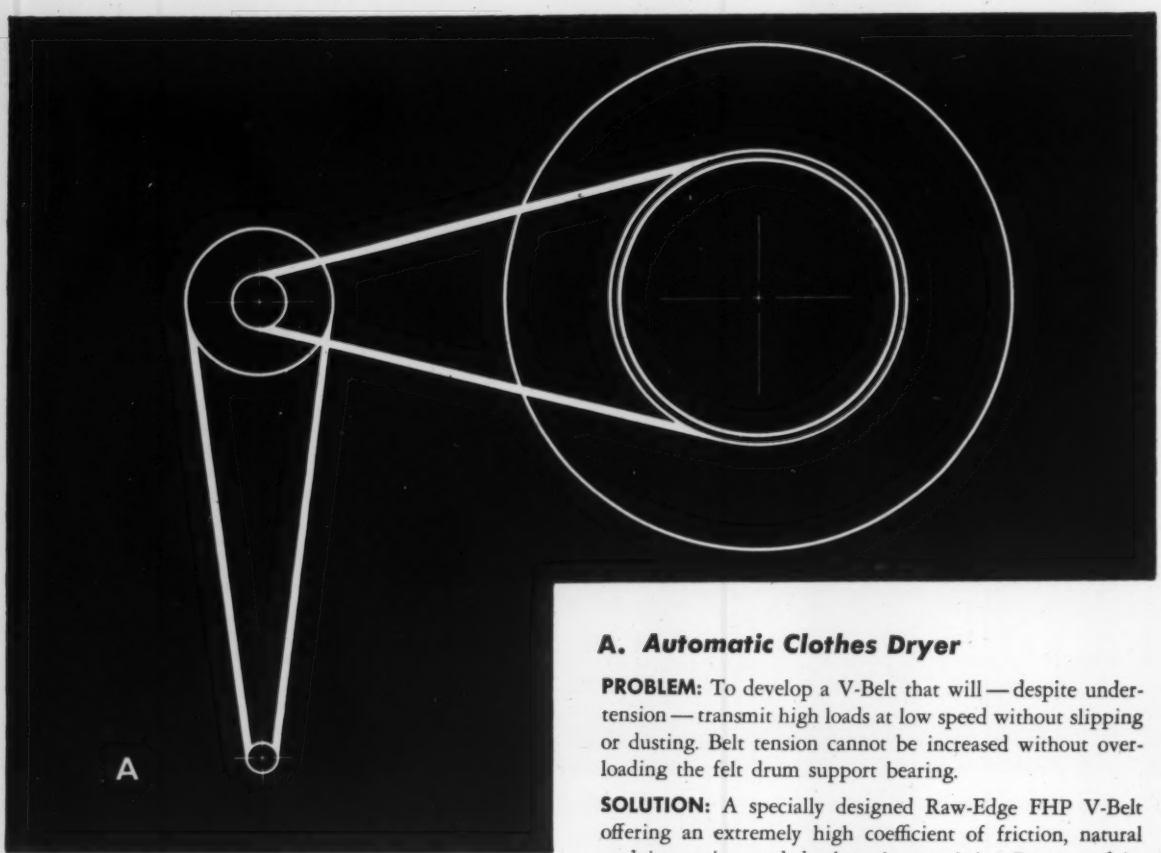
How 3 dissimilar drive problems were solved with special Dayton Raw-Edge FHP V-Belts

THE PROBLEMS:

A. To transmit high loads using sub-diameter pulleys

B. To transmit high loads at variable speeds without vibration

C. To transmit high loads with minimum V-Belt tension

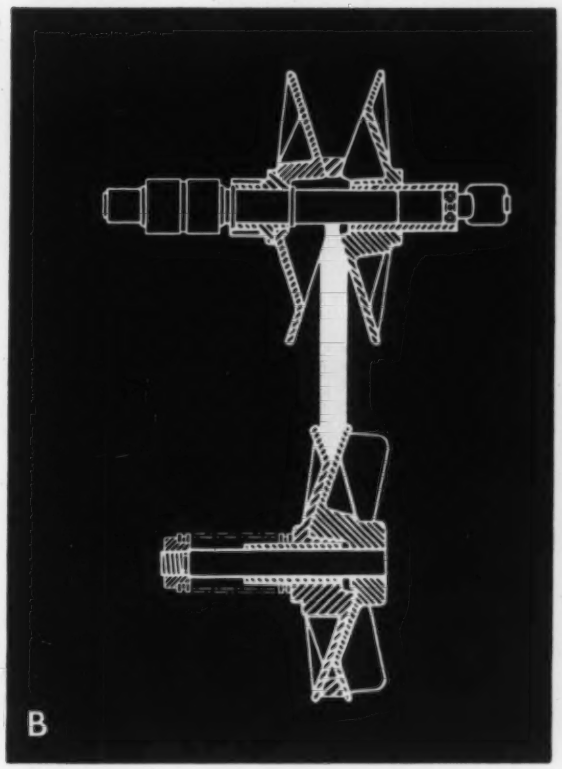


A. *A noteworthy feature of this automatic clothes dryer is the use of a rolled flange on the dryer drum as the final pulley in a 35:1 two-stage reduction drive. The dryer drum is supported by felt bearings.*

A. *Automatic Clothes Dryer*

PROBLEM: To develop a V-Belt that will — despite under-tension — transmit high loads at low speed without slipping or dusting. Belt tension cannot be increased without over-loading the felt drum support bearing.

SOLUTION: A specially designed Raw-Edge FHP V-Belt offering an extremely high coefficient of friction, natural wedging action, and dustless characteristics. Because of its high traction ability, the raw-edge belt will pull the load required without the high tension which would collapse the belt bearing. The inherently dustless characteristic of Raw-Edge V-Belts allows clean operation.



B. *Interdigitary pulleys are employed by a popular home workshop tool to provide an extraordinarily wide range of variable speeds within a limited drive space. By this unique method, the pitch diameter of each pulley can be varied from 1-1/2" to 5-3/16".*

B. *Multi-Purpose Home Workshop Tool*

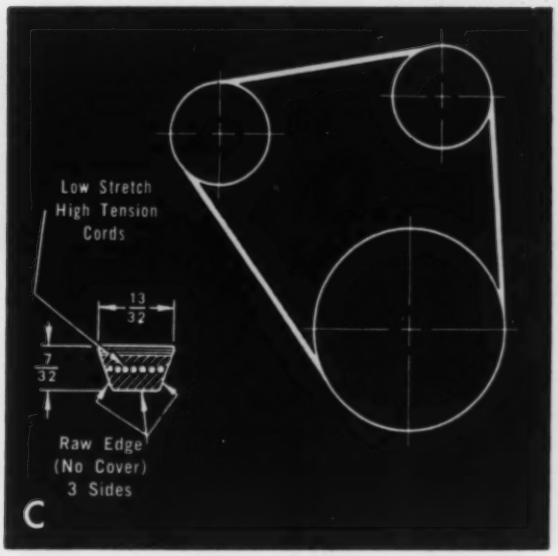
PROBLEM: To transmit heavy loads with interdigitating variable speed pulleys without vibration. The required V-Belt must not take a set due to long periods of idleness and — for safety — must slip under overload.

SOLUTION: A special Raw-Edge Die-Cut V-Belt compounded from special rubbers and fabrics which can be used only in Raw-Edge construction. A full plyed-up section, manufactured under especially close width and length controls, was the solution to this problem. The belt in use

— has the required coefficient of friction to transmit heavy loads and slip under overload

— won't take a set even when stored under tension for long periods

— has the ability to flex over small diameter pulleys



C. *Because of the extreme compactness of a space saving design, this automatic clothes washer employs small diameter pulleys.*

— resists twisting when operating over the interrupted surface of the interdigitary pulleys and thus avoids setting up vibration.

C. *Automatic Clothes Washer*

PROBLEM: Small diameter pulleys with a limited arc of contact caused belt slippage and premature failure in a drive operating at high speed and under heavy loads. Tension adjustment was limited and somewhat inaccessible.

SOLUTION: Employment of a special Raw-Edge Molded FHP V-Belt, with its high coefficient of friction and inherent wedging action, to attain high tractive effort despite the limited arc of contact. As a further refinement, the belt being furnished by Dayton is built with special "low stretch" cords in the strength section to minimize the need for tension adjustment. This solution made redesigning around larger pulleys and heavier belts unnecessary.

Dayton's V-Belt Engineering Service

For help on your drive designs, Dayton Engineers are at your service with the correct V-Belt to fit all your requirements.

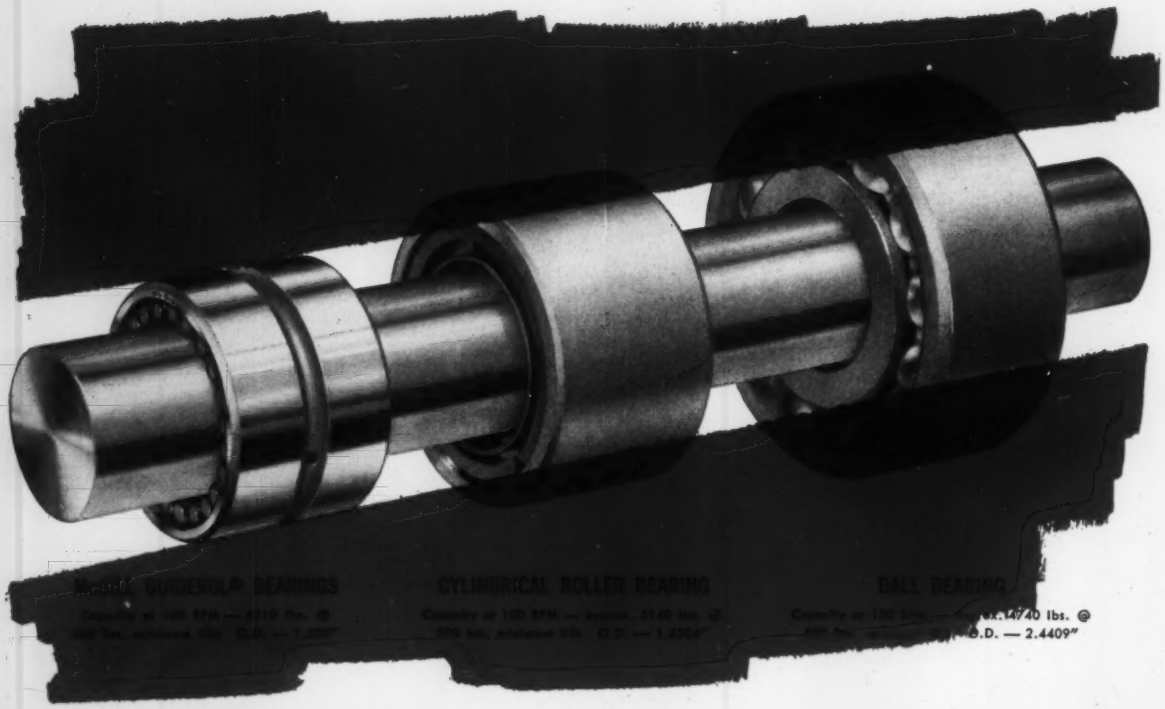
To contact one of these V-Belt Design Specialists or for more information on special Raw-Edge FHP V-Belts, write The Dayton Rubber Company, Industrial O.E.M. Division, Dayton 1, Ohio.

THE DAYTON RUBBER COMPANY, INDUSTRIAL O. E. M. DIVISION, DAYTON 1, OHIO

Dayton Rubber

WORLD'S LARGEST MANUFACTURER OF V-BELTS

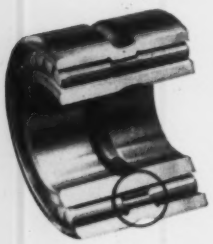
Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis.



GUIDEROL® BEARINGS SAVE RADIAL SPACE
. . . . . and still offer greater load capacity

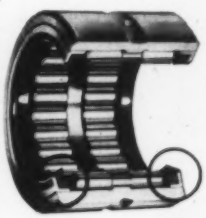
This graphic illustration demonstrates the radial space saving advantages of McGill GUIDEROL bearings that offer still greater capacity than the other two types of bearing compared. For a common 1" shaft, the GUIDEROL bearing GR-16 has an O.D. of only 1½" with a capacity of 6310 lbs. Compared to a cylindrical type roller bearing the GUIDEROL bearing requires ⅜" less housing space and offers 23% more capacity. A ball bearing for the same shaft uses almost an inch larger O.D. to carry 1500 lbs. less radial load.

CENTER GUIDED ROLLERS



GUIDEROL bearings pack more performance into smaller radial space. Their construction offers the inherent high capacity of a full complement needle bearing combined with effective roller control. Center guided rollers limit roller skewing tendencies and prevent binding under adverse conditions in either horizontal or vertical mountings. This qualifies GUIDEROL bearings for applications which are too heavily loaded for retainer type needle bearings, but are subject to misalignment that precludes the use of unguided needle bearings. Standard GR series GUIDEROL bearings are available, with or without inners, in shaft sizes from ⅝" to 9¼" with capacities ranging from 2880 lbs. to 128,670 lbs. (at 100 RPM).

LUBRICATION LOCKED IN, CONTAMINATION OUT; IN SEALED GUIDEROL BEARINGS



Pre-lubricated and sealed SG series GUIDEROL bearings are interchangeable dimensionally with standard GR series GUIDEROL bearings. They offer 5 possible seal combinations. Specify the sealed bearings for applications that are exposed to dust, dirt, grit or where accessibility for lubrication is a problem. Your McGill representative will be happy to assist you with special application problems. Ask him for recommendations or write the McGill Engineering Department.

For Complete Data on Dimensions, Capacities and Application of McGill Precision Needle Bearings, Send for Free Catalog No. 52A.

engineered electrical products

McGILL®

precision needle roller bearings

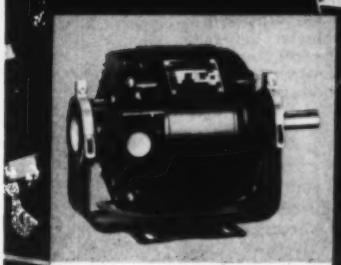
McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 NORTH LAFAYETTE ST., VALPARAISO, INDIANA

Here Knowledge Counts...

In a chess game, it's *knowledge* that pays off. And, when it comes to motors for appliance and equipment manufacturers, Emerson-Electric's team of skilled specialists (more than 100 engineers!) is ready to go to work for you *now*... with knowledge that pays off in your profit column.

Remember...

- Emerson-Electric produces *custom-engineered* motors to meet *your specific needs.*
- For more than 65 years, Emerson-Electric has been solving problems *like yours.*



Put this special knowledge to work for you! Call, wire or write Dept. M-363 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.

EMERSON-ELECTRIC *of St. Louis · Since 1890*

Circle 469 on Page 19

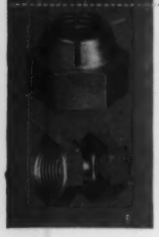
FASTENING SPECIALTIES BY *National*

Get more dependable holding power for better product assembly with these National SPECIALTY FASTENERS!

Lok-Thred® Bolts, Studs, Screws—Seal and lock against involuntary loosening... Lok-Thred re-forms the metal of the receiving thread under high compressive stresses into intimate contact with itself, eliminating all voids. Yet, it's fully re-usable. Requires no selective fits. Can be used with ordinary tools. Available in all sizes of bolts, studs, screws... No. 6 or larger.

Spin-Lock® Fasteners—Give you strength at low cost, with self-locking, ratchet-tooth action . . . Spin-Lock machine and tapping screws have angled teeth to permit fast, easy tightening. They require about 20% greater torque to loosen. Available in pan, truss, flat and hex heads; slotted or Phillips recessed heads; No. 4 to $\frac{3}{8}$" diameters, lengths from twice diameter and up.

Thread Cutting Screws—For joining metals or plastics without tapping... Use wherever it is desirable to remove rather than displace thread material. Four types: 1, 23, 25, and F cover most applications. Phillips or slotted heads, all styles, all sizes. Also type A and B tapping screws for fastening light sheet steel or light gauges of other metals.



Lock Nuts—Three types, to meet every requirement... 1. *Huglock*, for locking without seating and under adverse conditions. 2. *Marsden*, free-running until seated . . . for minimum-cost locking. 3. *Drake*, a two-piece design for use under severe stresses, shock, vibration. All types are all-metal, fully re-usable without loss of positive locking action.

Welding Fasteners and Weldnuts—Provide trouble-free assembly of fabricated metal parts... Use National welding fasteners when primary fasteners must be cleanly welded into exact position. National's complete line of projection welding screws and nuts is available in stock sizes, for optimum welds in materials .030 to $\frac{1}{4}$" thick. We will develop special designs for you.

Flex-Head® Locking Screws—Self-locking, highly resistant to fatigue, shock, impact... Tight locking results from flexing of the head and axial spring tension produced when fully torqued against a rigid seat. Flex-Head screws are identical in dimension, and interchangeable with standard machine screws. Made of 1022 steel and heat-treated for top strength.

Tuff-Tite® Cushioned Fasteners—Seal openings, eliminate vibration noises, absorb shock... Pre-assembled neoprene washers also prevent finish marring! Available as tapping screws, thread cutting screws, machine screws, roofing bolts, stove bolts, or wood screws; with Phillips or slotted heads; pan, round, truss or hex head styles.

Place® Bolts—Self-locking...resist impact, shock and fatigue failure by controlled spring action of reinforced, diaphragm head... Place bolts resist involuntary loosening when rigidly seated. Typical uses: connecting rod bolts, main bearing cap screws, flywheel bolts. Available in high carbon or alloy steel, in a wide range of sizes.

Save yourself time and trouble in searching for the right fastener. Make National your *one source* for standards, specialties and special designs. Our standard line includes all types and sizes . . . nuts, cap and set screws, machine bolts, carriage, step and elevator bolts, plow bolts; Phillips recessed head, or slotted, Sems, machine screws, wood screws; stove bolts, pipe plugs, cotter pins and rivets.

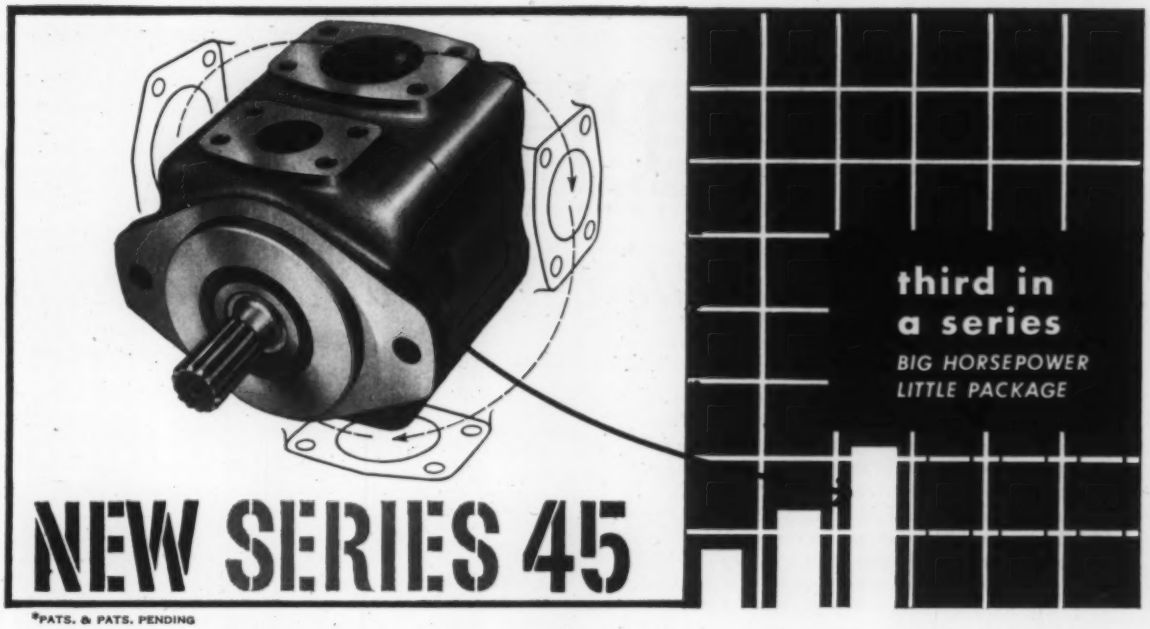
National can supply any nonstandard fastener, or design and produce specials for you. Write for National's *Special Products* booklet, or for information on the fastening specialty that interests you.

THE NATIONAL SCREW & MFG. CO. • CLEVELAND 4, OHIO

Fasteners **Hodell Chains** **Chester Hoists**

National PRODUCTS

Circle 470 on Page 19



*PATS. & PATS. PENDING

VICKERS® "high performance" vane pump

• high speed • high pressure • high efficiency • high service life

NEW COMPACT DESIGN . . . much more horsepower than previous pumps of the same package size.

NEW VANE CONSTRUCTION . . . positive vane tracking at all operating speeds assures efficient operation at increased speeds and pressures.

NEW SIZES not previously available . . . answers mobile equipment designers' need for greater hydraulic horsepower in limited space.

NEW PARTS INTERCHANGEABILITY . . . many common parts for single and double pumps (two pumps on the same shaft in one envelope). Lessens inventory requirements.

NEW 4-BOLT SAE FLANGE CONNECTIONS . . . will also accommodate user's 2-bolt flanges of the proper design.

NEW 2-BOLT MOUNTING (SAE 1959 STD.).

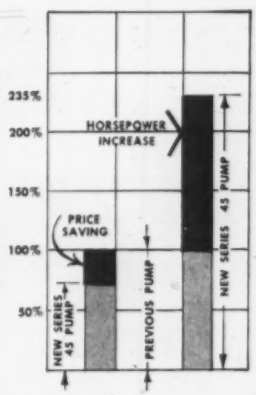
NEW 4-POSITION COVER inlet can be rotated in 90° increments with respect to outlet.

NEW REPLACEABLE PUMPING CARTRIDGE . . . all wearing parts of pump are incorporated in one replaceable cartridge. Easy field replacement without removing pump from its mount. Cartridges available in kit form.

MUCH MORE HORSEPOWER PER DOLLAR

The striking increase in horsepower per dollar of the Series 45 over previous pumps of the same delivery capacity is shown in the graph to the right. Maximum horsepower is more than double (235%) and price is lower by 35%.

This is the third unit released in the new complete line of "High Performance" Pumps, single and double. The first (Series 25) is available in 12, 14 and 17 gpm sizes and the second (Series 35) comes in 21, 25 and 30 gpm sizes (at SAE rating of 1200 rpm and 100 psi). This new Series 45 pump is available in 35, 42 and 50 gpm sizes.



The table below shows characteristics

Model Number	Delivery—gpm		Input Horsepower @ 2000 rpm 2000 psi	Package Size†	Weight
	1200 rpm 100 psi	2000 rpm 2000 psi			
2V35A-1*10	34	52	71	L. 7¾" W. 6¼" H. 6½"	69 Lbs.
2V42A-1*10	41	63	86		
2V50A-4*10	48	75	103		

†Exclusive of Shaft Extension and Mounting Lobes

8201

Write for new illustrated Bulletin No. M5108 for further details and performance characteristics.

VICKERS INCORPORATED
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Mobile Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
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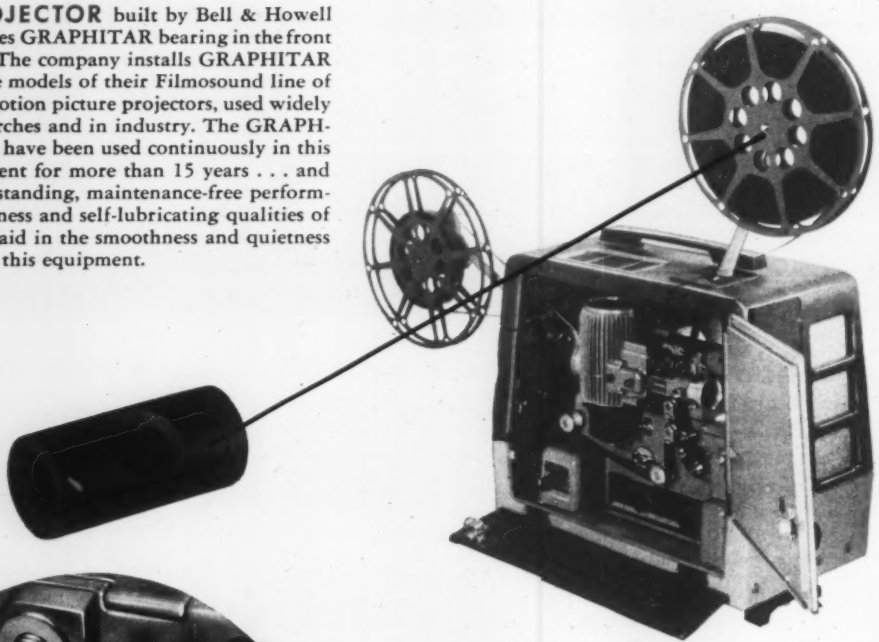
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

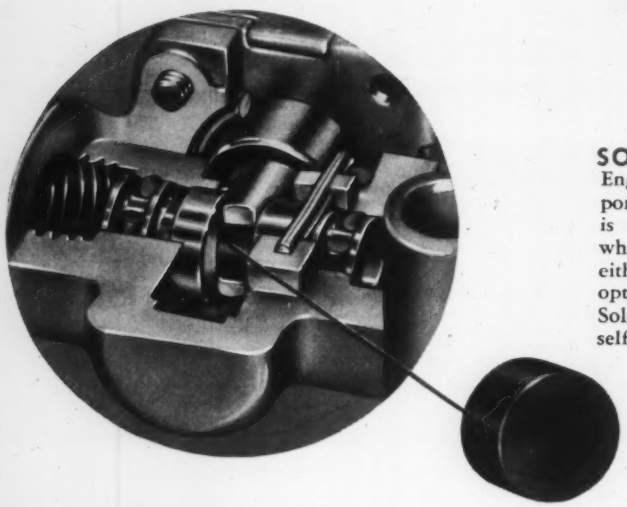
this is GRAPHITAR®

(CARBON-GRAPHITE)

successful in a wide variety of applications

MOVIE PROJECTOR built by Bell & Howell Company utilizes GRAPHITAR bearing in the front reel assembly. The company installs GRAPHITAR bearings in five models of their Filmosound line of 16mm sound motion picture projectors, used widely in schools, churches and in industry. The GRAPHITAR bearings have been used continuously in this line of equipment for more than 15 years . . . and have given outstanding, maintenance-free performance. The hardness and self-lubricating qualities of GRAPHITAR aid in the smoothness and quietness of operation in this equipment.

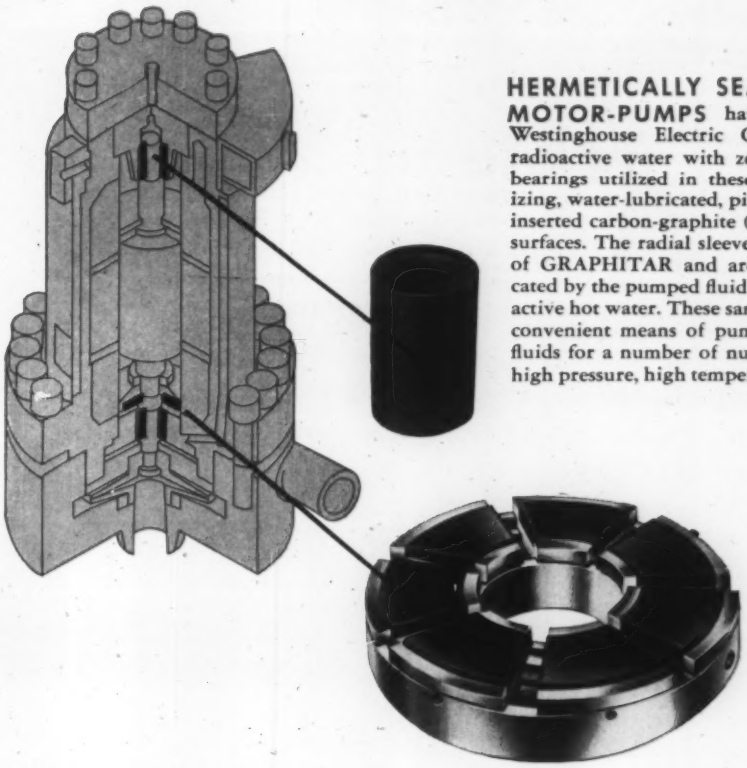




SOLENOID VALVES manufactured by Valcor Engineering Co. for use in guided missiles incorporate a floating seal of GRAPHITAR. This seal is a precise, optically flat GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. Solenoid valve improves with use due to unique self-lapping action of GRAPHITAR.

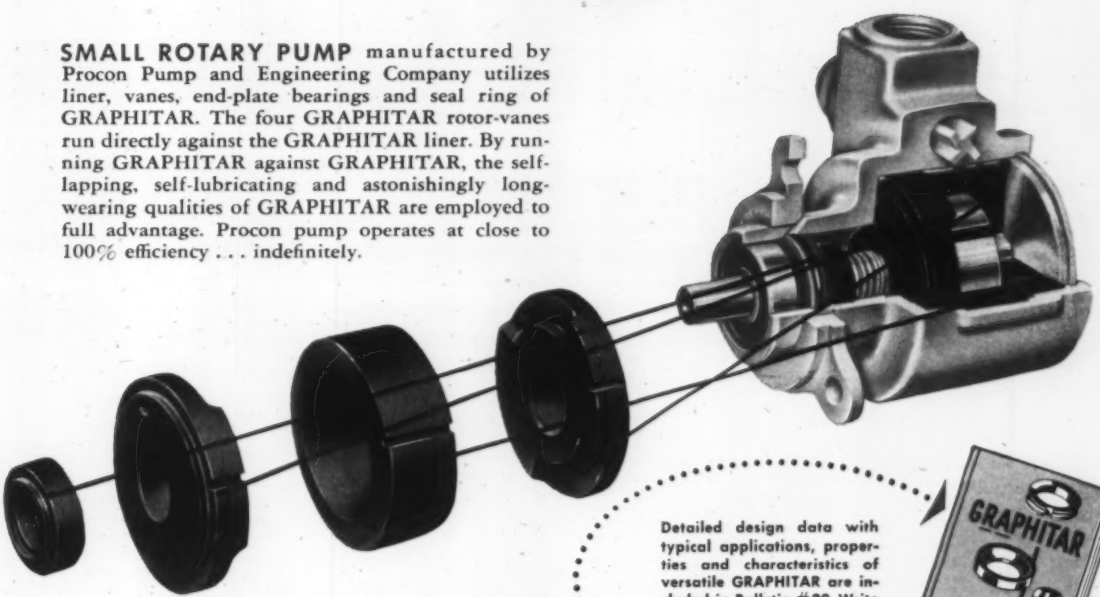
THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



HERMETICALLY SEALED MOTOR-PUMPS have been developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. The thrust bearings utilized in these pumps are self-equalizing, water-lubricated, pivoted-pad bearings with inserted carbon-graphite (GRAPHITAR) bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only, in this case, radioactive hot water. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

SMALL ROTARY PUMP manufactured by Procon Pump and Engineering Company utilizes liner, vanes, end-plate bearings and seal ring of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against the GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR, the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage. Procon pump operates at close to 100% efficiency . . . indefinitely.



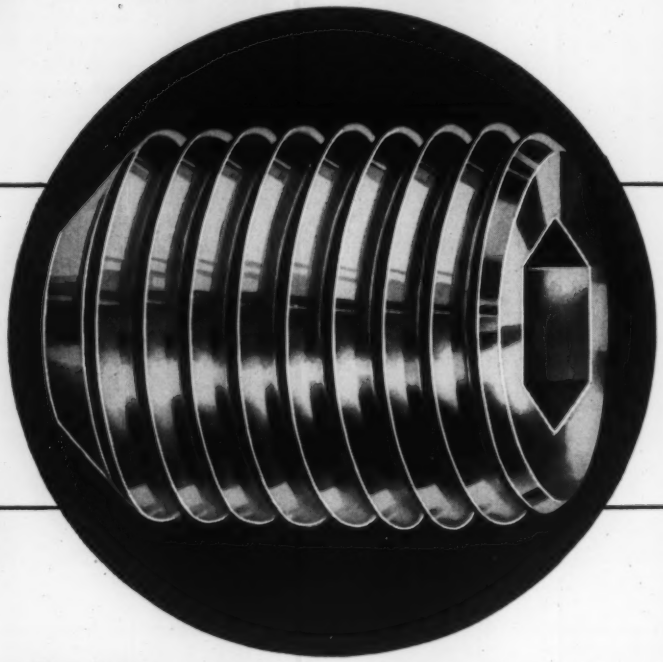
Detailed design data with typical applications, properties and characteristics of versatile GRAPHITAR are included in Bulletin #20. Write for your free copy.

R-265-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Problem: *"Secure pulley to shaft with set screw. Head of screw should be flush with pulley collar to prevent injury to personnel. Set screw must hold firmly under vibration. Space for tightening and loosening is limited . . ."*



Solution: *HOLO-KROME SOCKET SET SCREWS. Made of special analysis alloy steel heat-treated to 48-52 Rockwell "C" hardness. Hex sockets, forged by H-K's new methods, are scientifically proportioned for highest strength and trouble-free driving. Internal hex socket drive permits tightening and loosening in limited clearance, eliminates protruding, dangerous heads. Threads are Unified Class 3A Fit for maximum holding power under vibration.*

For the finest in Hex Socket Screws . . . for unmatched Same-Day Service, the name to remember is Holo-Krome.

HOLO-KROME
SOCKET SCREWS

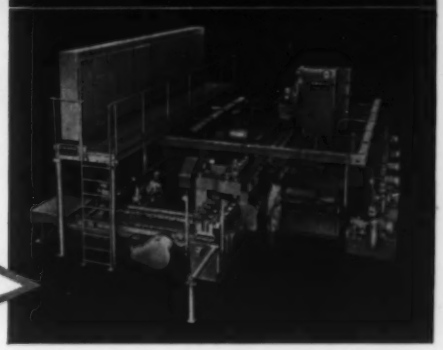
THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

SOLD ONLY THROUGH AUTHORIZED HOLO-KROME DISTRIBUTORS

Circle 472 on Page 19

Installed view of FAWICK CB Airflex Clutches, 16 of which drive 40 spindles with a disengage-retract-engage-drive sequence. Units conform to JIC standards, require only routine inspection and preventive maintenance.

CROSS Chucking Transfer-matic, an outstanding example in machine tool automation. Each of three Transfer-matics at Ford's Sterling plant turn and bore differential cases at a rate of 368 pieces per hour, with the work pieces chucked and not released until all operations are completed. They operate 16 hours a day, 5 days a week.



Fawick Clutches here... provide precision automation HERE!

■ Sixteen FAWICK CB Airflex Clutches provide the precision power-transmission link between driving members and 40 driven spindles. In this outstanding automated operation of the Cross Chucking Transfer-matic, FAWICK Clutches automatically disengage and retract from the driven drums at the end of each cycle. As the work pallets are indexed, the clutches engage and drive the next cyclic set of spindles. All operations and transfer of pallets to their new stations are simultaneous.

This installation is another example of the flexibility that FAWICK clutches provide to industry. *Instant response, lifetime "new clutch" action, full power transmission, greater operating safety and freedom from maintenance* are all "automatic" advantages supplied by FAWICK Clutches.

For detailed information contact your nearest FAWICK representative or write to the Home Office, Cleveland, Ohio.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

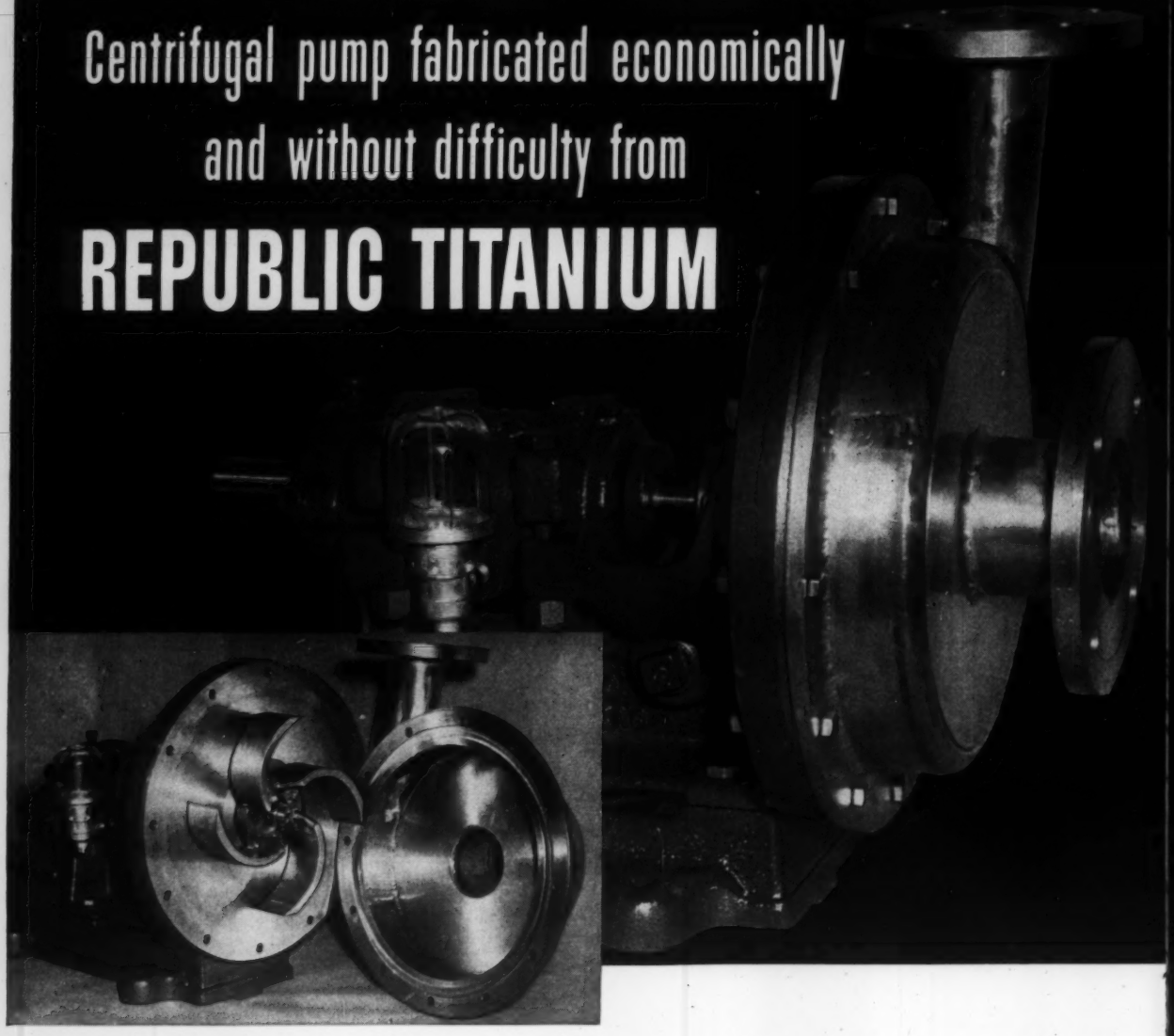
FAWICK AIRFLEX

FAWICK AIRFLEX CLUTCHES • AIR RING BRAKES • ROTORSEALS • SAFETY CLUTCH CONTROLS

Circle 473 on Page 19

Centrifugal pump fabricated economically and without difficulty from

REPUBLIC TITANIUM



Mission Manufacturing Company, Houston, Texas, has added a worthy companion to its full line of centrifugal pumps for corrosive and abrasive applications. Shielded-arc welding techniques now permit the use of titanium in its maximum corrosion-resistant form for particularly severe pumping applications.

The pump shown above was fabricated by shaping, welding in an inert gas atmosphere, and machining. It is being used by a leading chemical company to handle ferric chloride at temperatures of about 212°F. The finished pump, incorporating the exclusive Mission Concentric Casing, contains 34 pounds of Republic Titanium.

Performance ratings are essentially similar to those obtained for cast iron or corrosion-resistant alloys. Fewer pump sizes are required because the flat characteristics of Mission's impeller design provide a wide operating range and sustained efficiencies.

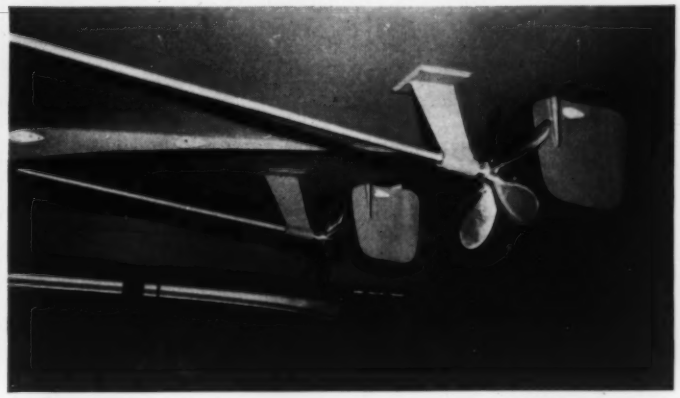
The entire fabricating operation was performed without difficulty and with little change in procedure as compared to other materials of construction.

Does this application of Republic Titanium spark an idea for your product that needs to be strong, lightweight, and corrosion-resistant? Republic Metallurgists and Machining Specialists will help you apply titanium's advantages now.

Republic produces commercially pure titanium and titanium alloys in ingots, billets, hot rolled and cold finished bars, plates, sheets, and strip. Mail the coupon for more information on these titanium forms, or for metallurgical and machining assistance.

SAVINGS IN MACHINING AND PRODUCTION COSTS of Ace Screw Extractors are obtained by the Henry L. Hanson Company with the help of Republic Cold Drawn Leaded Alloy Steels. Rolling of the extractor spirals formerly required several passes, each followed by an annealing operation. Now, with Republic Leaded Alloy, separate passes can be made deeper, reducing the total number of steps. And, because cold drawing improves the machinability of any given analysis, savings in machining costs are secured. Republic Alloys, Types 4140 and 4150, also provide a high degree of hardness and toughness. These properties in combination with scientific heat treating make the extractors practically unbreakable. Get all the facts on the advantages of Republic Cold Finished Alloy Steels. Mail the coupon today.

LOWER COSTS, IMPROVE QUALITY, INCREASE PRODUCTION with Republic Cold Drawn Special Sections. Because they are formed to the predominating cross-section of the part, Republic Special Sections eliminate or greatly reduce required machining. Results are faster output and lower cost. Also, since cold drawing improves the physical properties of any given analysis, completed parts are stronger and longer wearing. Other advantages may include improved appearance and simplified design. Send coupon for complete facts.



IMPROVED PRODUCT PERFORMANCE is reported by Roamer Steel Boats, Division of Chris-Craft Corporation, since switching to Republic Cold Finished Stainless Steel Bars. Vibration, a mechanical problem caused by out-of-true drive shafts, has been reduced to a minimum by Roamer through standardization of stainless shafts for their line of pleasure cruisers. The shafts are machined from uniformly straight Republic Cold Finished Stainless Steel Bars, Type 304. The bars meet Roamer's strict, maximum tolerance requirement of .006″ runout in 72″ of shafting. Stainless steel shafts also provide high strength and outstanding corrosion resistance. Republic specialists will help you use Cold Finished Stainless Steel Bars to best advantage. Mail coupon for more information.

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World's Widest Range of Standard Steels and Steel Products

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☐ Have a Titanium Machining Specialist call.
Send more information on:
☐ Titanium ☐ Cold Drawn Leaded Alloy Bars
☐ Cold Drawn Special Sections
☐ Cold Finished Stainless Steel Bars

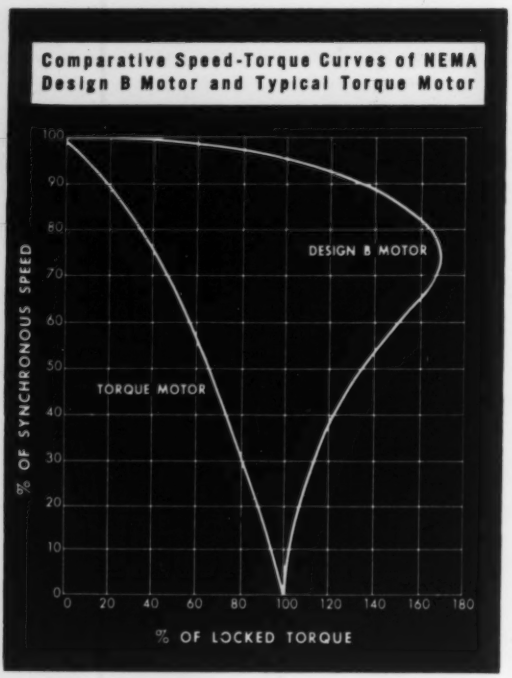
Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

SELECTING TORQUE MOTORS

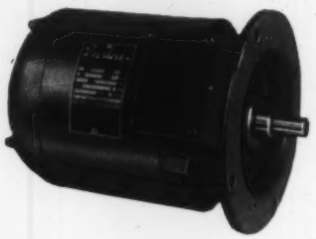
The torque motor, unlike any other electric motor, is a special from the word go. That situation alone makes Peerless one of the best sources for torque motors in ratings from 2 oz. in. to 200 lb. ft.

Torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

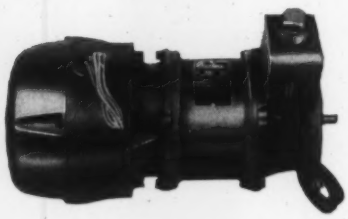
All standard frame sizes; all types of mountings; high torques; special paint and varnish treatments; and Class A, B and H insulation are available from Peerless. Torque motors require unusually close cooperation between the motor supplier and the customer's engineers. This cooperation is a Peerless specialty. We will work with you to produce the one torque motor that powers your product best.



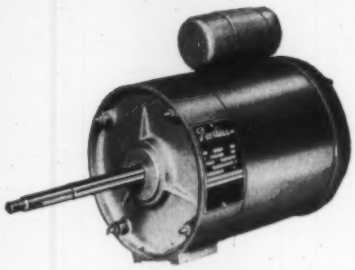
The speed-torque curve varies from that of a conventional motor. The torque motor curve is almost linear. Maximum torque occurs at the stalled position. For this reason, torque motors are used most often where a holding or resisting force is required.



Weather-Tight Special Flange

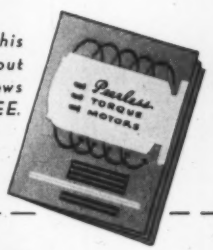


Explosion-Proof Torque Motor with Brake



Special Flange Reversing Hoist Motor Single Phase

NEW TORQUE BULLETIN-This bulletin outlines basic facts about Peerless torque motors and shows applications. It is available FREE. Write for it today.



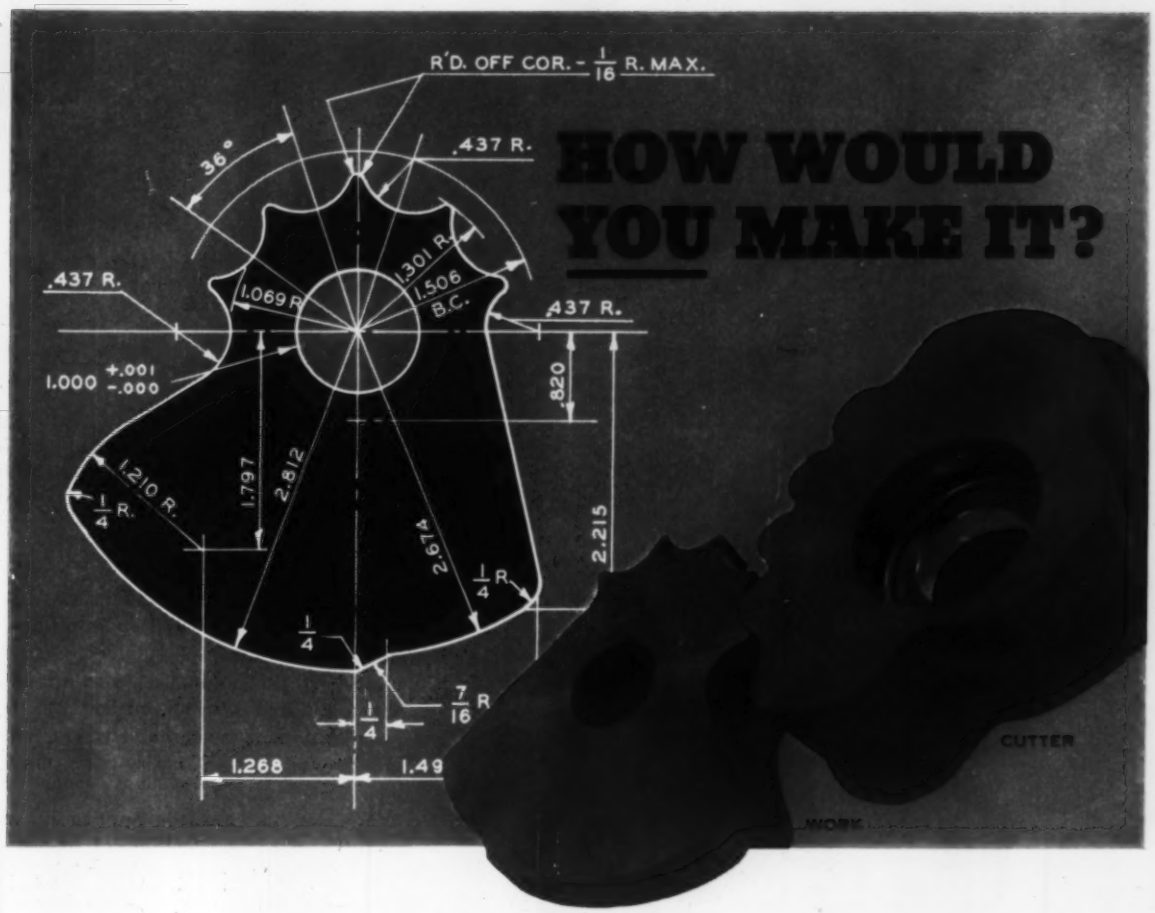
ELECTRIC MOTOR DIVISION

THE Peerless Electric® COMPANY

FANS · BLOWERS · MOTORS

1520 W. MARKET ST. · WARREN, OHIO

Circle 475 on Page 19



Cams and other non-circular shapes in almost unlimited variety can be generated accurately and at low cost on the Fellows Gear Shaper. In many cases, the easy versatility of the machine permits a single set-up where other methods of production would require a series of costly set-ups and operations.

The cam shown above is an example. It was generated in a single operation, using the cutter (shown at right, above) specially designed and manufactured by Fellows for the job. Set-up was simple, production was fast, accurate and inexpensive.

The same Fellows Gear Shaper, using appropriate cutters, can produce internal and external spur and helical gears, gears close to shoulders or in recesses, tapered gears, face gears and clutches. The advantages of the Gear Shaper are described and illustrated in "The Art of Generating with a Reciprocating Tool." This booklet, although not new, contains a wealth of information valuable to designers. We have distributed over 10,000 copies since 1951. If you would like one, just write us.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE

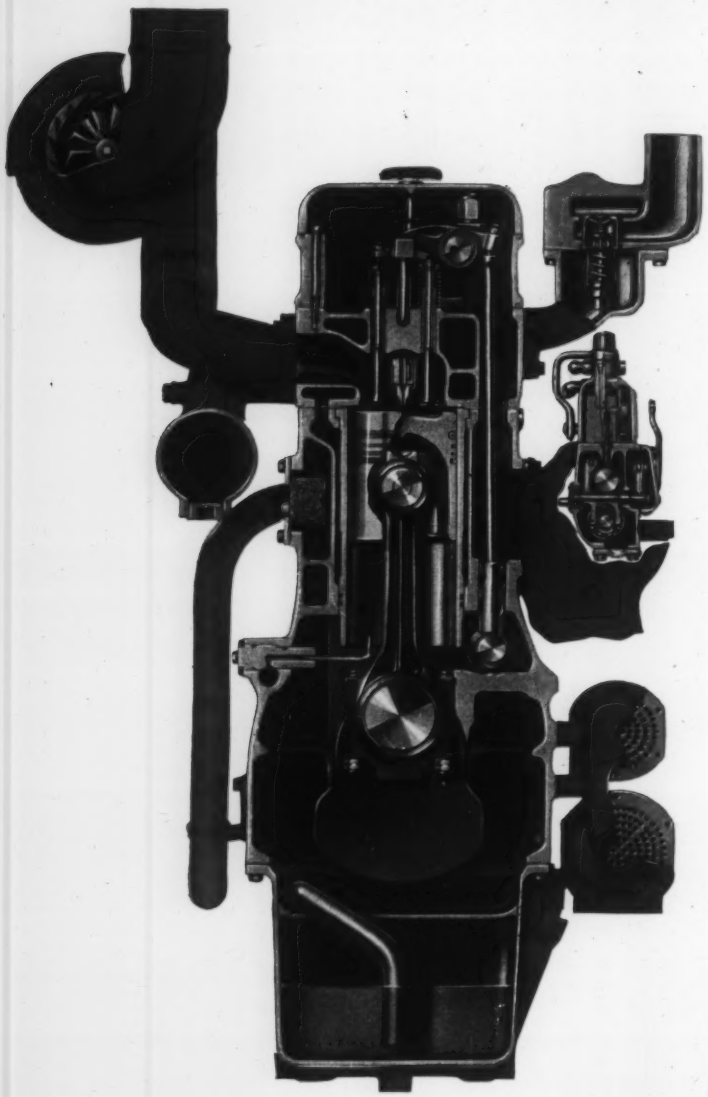
Fellows Gear Production Equipment

Circle 476 on Page 19

NOW FOR THE FIRST TIME

NEW 385

INTERNATIONAL® UDT



Here's the all-new 385 max. hp International UDT-817—a compact, heavy-duty 4-cycle, 6-cylinder engine thoroughly proven in six years of development and testing—backed by 26 years of experience manufacturing and selling over 400,000 heavy-duty diesel engines.

Designed for versatile application in all types of rugged hauling, excavating, construction, industrial and oil field equipment, the UDT-817 diesel answers the demand for dependable high power and lower cost of operation.

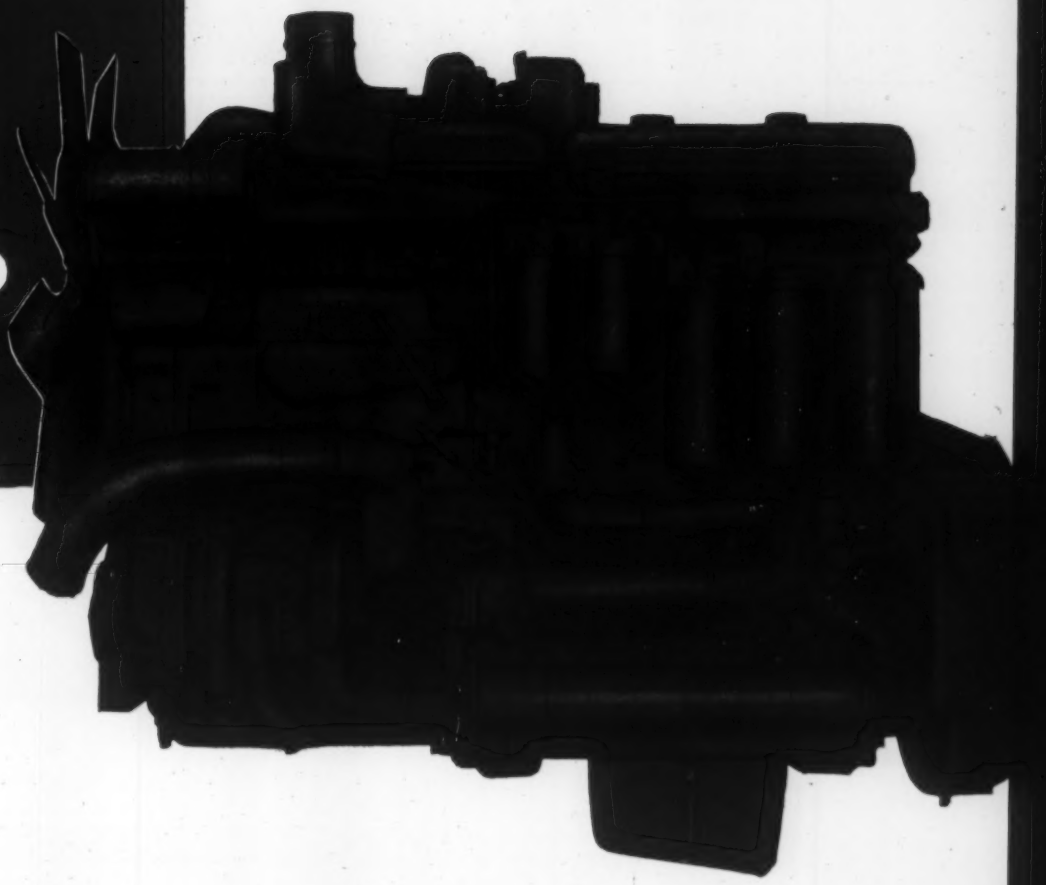
A wide variety of accessory equipment including air cleaners, flywheels for leading makes of torque converters and clutches, torque converter cooler, air control compressors, safety shut-offs, instruments and engine controls can be furnished to meet your installation requirements. Base, radiator, hood and dash, clutch and power take-off are available for complete power units.

For more specific information or application assistance, merely write or call International Harvester Co., Construction Equipment Division, Melrose Park, Illinois.

BRIEF SPECIFICATIONS

Type	4-cycle turbocharged
Bore and Stroke	5⅜ x 6"
Number of Cylinders	6
Displacement	817 cu. in.
Max. hp	385 @ 2100 rpm
Rated hp	375 @ 2100 rpm
Max. Torque	1,040 lbs. ft. @ 1400 rpm
Compression Ratio	16:1
Weight	3,540 lb.
Lbs. per max. hp	9.2
Length, fan to flywheel	61½"
Height	56½
Width	39½"
Flywheel housing SAE	No. 1

hp. 817



Features that add dependable, economical power to any product

- Fast direct starts with 24-volt electrical system.
- Direct injection of fuel under pressures to 20,000 psi by individual camshaft actuated multi-orifice injectors.
- Exclusive IH twin plunger metering pump directs equal and precise amounts of fuel to each injector in proper firing order according to load and speed demands.
- Turbocharger puts waste energy in exhaust gases to work for higher power output and lower fuel consumption.
- Dual intake and exhaust valves for free breathing efficiency.
- Positive valve rotators keep valve seats free of deposits.
- Aluminum alloy pistons working in replaceable wet cylinder sleeves with velocity swirl-flow water cooling on outside, jet oil cooling on inside, for long life operating temperatures.
- Fully counterbalanced Tocco-hardened crankshaft with seven big main bearings and torsional vibration damper for smooth, dependable, high power output.

International® Construction Equipment

International Harvester Co., 180 North Michigan Ave., Chicago 1, Ill.

A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom-Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

Circle 477 on Page 19

electric motion control facts

for IDEA MEN

Electric clutches control missile-firing circuit

Fit into compact wing-mounted assembly

The manner in which cam rotation is controlled in this air-to-air missile-firing timer may give you some ideas for improving your product or developing new ones.

The trick was to design a sequence timer for firing air-to-air missiles and keep it compact enough to fit into the wing of a fighter plane. It had to be lightweight, simple, and maintenance free. In it, clutches would have to function at temperatures from −67° F to +275° F—a 342° spread.

The Avionic Division of John Oster Manufacturing Company, Racine, Wis., designed the timer (Fig. 1) using a 0.1 oz in. rated, 12,000 rpm motor to turn three separate timing cams at different speeds.

Three Warner stationary-field electric clutches (less than 1″ in diameter) provided a simple, compact device for coupling the cams to their input shafts. Electromagnetic clutching simplifies operation of the cams in response to signals from the fire control sequencer. These signals energize the clutch field *directly*, with current supplied to the coil from pigtail leads. The torque-producing electromagnetic flux created by energizing the coil with 24 volts of d-c, passes through the stationary field, across an air gap to the rotor pole faces and armature. This couples the rotor and armature (each keyed to their respective shafts) transmitting rotary motion from the drive shaft to the timing cams.

The result is packaged, plug-in type actuation without complex mechanical linkages, solenoids, or rigid piping. Clutches maintain precise air gaps and clearances, withstanding repeated impacting caused by rotation of the carriage and motion of the plane.

Environmental extremes no problem

Temperature requirements proved to be no problem for the Warner clutches.

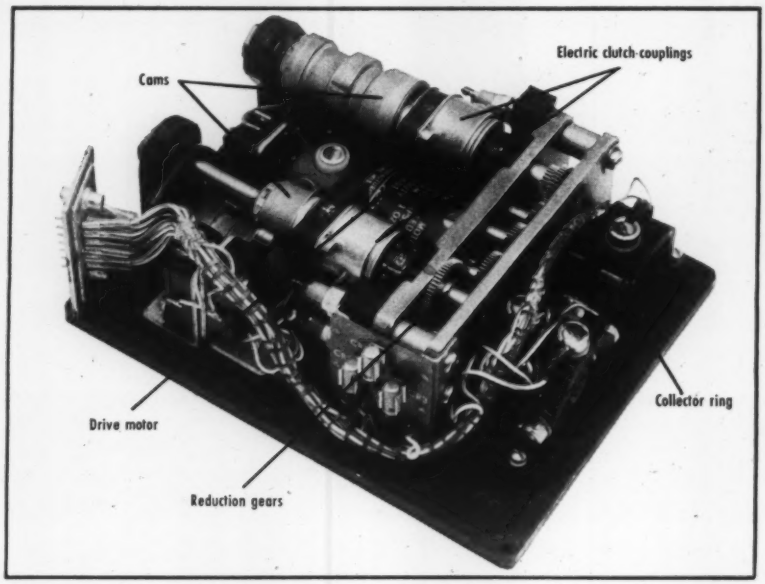
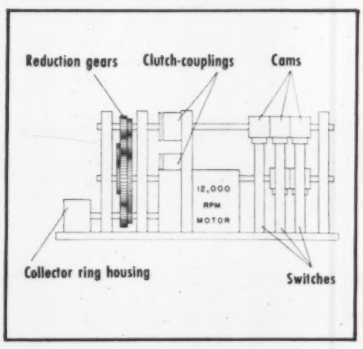


Fig. 1—Warner electric clutch-couplings operate on 28 volt d-c and require a maximum of 6 watts to produce rated torque of 24 ounce-inches.

Simple design, positive no-slip engagement, and ability to dissipate heat rapidly eliminate any need for lubrication or special cooling. Stationary-field design and low current actuation rule out arcing problems at low temperatures or high altitudes.

Fig. 2—For installation in wings of fighter aircraft, this firing sequence timer uses three Warner electric clutch-couplings to transmit shaft rotation to timing cams automatically.



A new dimension in machine design

Warner's compact electromagnetic clutches and companion-sized brakes open new doors to design of automatic drives for aircraft, missiles, and business machinery. There's virtually no limit to motion control possibilities with clutches and brakes that: 1) engage and release in milliseconds, 2) operate directly from actuating current, and 3) permit stepless torque adjustment.

SEE this desk-top demonstration

Your Warner field engineer has a plug-in demonstrator, with control for adjusting torque, to demonstrate the versatility of electric brakes and clutches. Phone him, or write to:

WARNER ELECTRIC BRAKES AND CLUTCHES

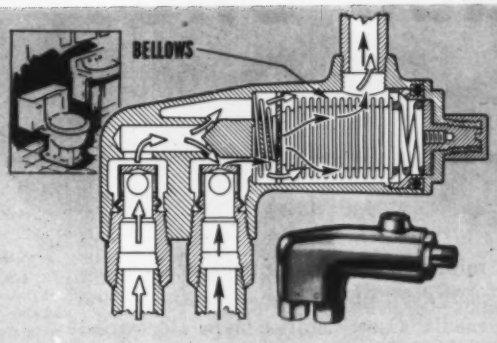
Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

Circle 478 on Page 19

DESIGN FOR

BEST PERFORMANCE, LOW COST

with **Flexonics** BELLOWS

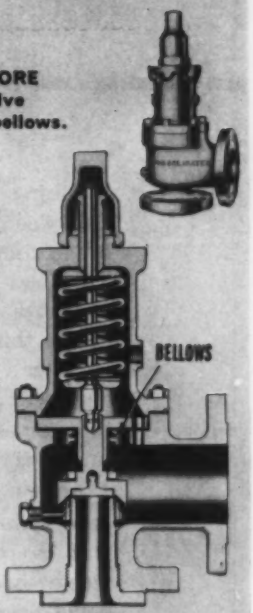


KOHLER of KOHLER eliminates closet condensation with thermostatic supply valve.

A Flexonics bronze bellows is the heart of the new Kohler thermostatic valve designed to mix water from the hot and cold lines to deliver tempered water to the closet tank . . . eliminating annoying condensation (sweating). The fast response of the bellows keeps water in perfect temperature balance . . . automatically. Valve requires no adjustment for seasonal variations in water temperature. Another example of the adaptability of Flexonics bellows in designing for best performance at low cost.

MANNING, MAXWELL & MOORE Consolidated Safety Relief Valve features FLEXONICS sealing bellows.

After long investigation and literally thousands of tests, a Flexonics stainless steel, two-ply bellows was selected for the Consolidated Safety Relief Valve. The bellows isolates contaminants, corrosion, or viscous fluids from the working parts of the valve. It is designed to allow a maximum variation in back pressure at the valve outlet while at the same time maintaining the important characteristics of high capacity, no change in set pressure, and limited blowdown changes.



For design applications that involve the measurement of pressure or temperature...a flexible sealer...or even low-torque power transmission – a Flexonics Bellows can be your answer. Send an outline of your bellows application – the Flexonics Application Engineering Staff will be pleased to make recommendations. If you prefer *write for the Flexonics Bellows Design Guide . . . 20 pages of valuable information.*

B-500

TOMORROW'S ENGINEERING TODAY

Flexonics

BELLOWS

FLEXONICS CORPORATION • 1339 S. THIRD AVENUE • MAYWOOD, ILLINOIS

Divisions

INDUSTRIAL HOSE • EXPANSION JOINT • BELLOWS • AERONAUTICAL • AUTOMOTIVE

Flexonics Research Laboratories, Elgin, Illinois

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Circle 479 on Page 19

We Couldn't Buy A

So We Made One!

During the Second World War Rockwood was producing thousands of fire-fighting nozzles for the U. S. Navy. They had to be tested and tested *completely*. Every valve Rockwood tried during this severe testing began leaking after a month of service. Rockwood engineers solved the problem with a unique valve with a ball and seat — and it worked!

After three years of uninterrupted service this valve was taken apart. It was in perfect operating condition! Rockwood had pioneered a valve that could operate over two million times without leaking! The difference of true precision engineering and unique design had payed off.

When the ball is forced against the resilient seat it completely seals itself. When pressure is low, a spring behind the valve ball, acting through the ball retainer, forces the ball against the seat for positive sealing. The ball floats to assure perfect alignment of ball and seat every time. *You get a positive seal — with water, oils, gases or solids!*

Full Round Flow! The friction loss through Rockwood Ball Valves is negligible.

Long Life! Corrosion and erosion are minimized by the straight through design even under high velocities of the media. Case histories show Rockwood Ball Valves perform perfectly even after they've been cycled thousands of times!

Quick Operation! A quarter turn of the handle opens or closes the valve. Complete accessories for air operation utilizing air cylinders are stocked for all sizes and types.

Maintenance is practically nil! Rockwood Ball Valves require no lubrication. No special tools are required for reseating, etc.

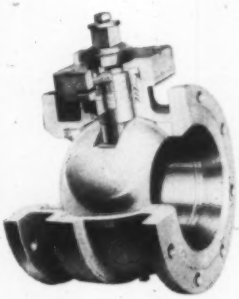
Variety and Versatility. The next page shows a small sample of the variety. Our 78-page catalog lists the rest! And Rockwood Ball Valves are available in all types of materials to meet the many requirements of industry. Many accessories are stocked to meet particular needs.

If you don't find the valve you want on the next page ask us! When special features or designs are necessary, complete research, engineering and manufacturing facilities are available.

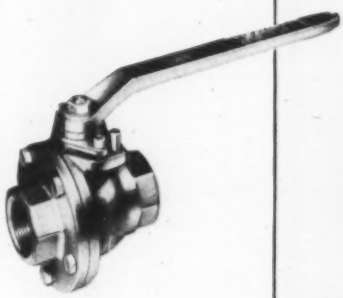
Rockwood Ball Valves are tested and listed by Underwriters' Laboratories, Inc.

Trouble-Free Valve

Some Of The Many Popular Rockwood Ball Valves

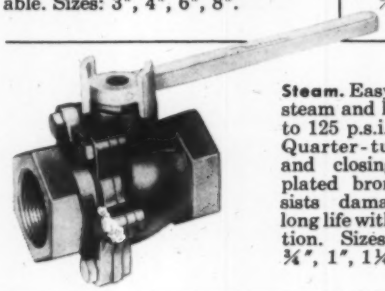


Stainless Steel. Eliminates the usual stainless steel galling. Chevron Teflon stem packing is adjustable. Opens and closes with a quarter-turn. Synthetic rubber seats and operating levers available. Sizes: 3", 4", 6", 8".



Stainless Steel. For chemical service at temperatures from −100°F to 400°F. Same advantages as larger stainless steel type. Sizes: ⅜", ½", 1¼", 1½", 2".

Forged Brass. All-purpose design for water, oil, gas, etc. Handle can be located in eight different positions for easier opening and closing. Forging body and cap gives more strength, density and soundness. Sizes: 1¼", 1½", 2".

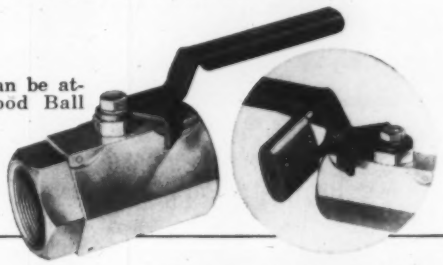


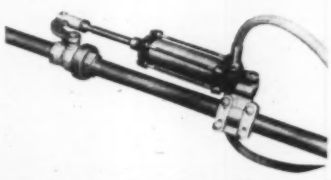
Steam. Easy handling of steam and hot water up to 125 p.s.i. and 350°F. Quarter-turn opening and closing. Chrome-plated bronze ball resists damage, assures long life without lubrication. Sizes: ⅜", ½", ¾", 1", 1¼", 1½", 2".

Top Entry. Ideal where frequent cleaning and repair are required. Cap removal design, pioneered by Rockwood, permits easy access to parts for valve repair while in the line. Threaded end sizes: ½", ¾", 1", 2½". Sweat end sizes: ½", ¾", 1".

Other Rockwood Advancements

Snaplock Handle. Can be attached to Rockwood Ball Valves of bar stock carbon steel and stainless steel. Prevents accidental opening and closing.





Air-Operator. For hard-to-reach valve locations. Available in a complete package unit, can be mounted in four different positions around a Rockwood Ball Valve and enables control of one or several valves from a central control board.

For complete details on all Rockwood Full, Round Flow Ball Valves write for new catalog to Rockwood Sprinkler Company, 1109 Harlow Street, Worcester 5, Mass. Distributors in all principal industrial areas.

ROCKWOOD BALL VALVES

Circle 480 on Page 19

Baffling is the art of filtration...

That's why good engineers throughout industry make use of Dollinger's 35 year experience in making dry type filters for practically every known application. Quite possibly, the problem you have today was solved years ago by Dollinger research. You owe it to yourself, and your company, to find out what Dollinger knows before spending more time developing your own solution.

We don't claim to have "all the answers" on filtration, only a few engineering "short-cuts" that will certainly save you many experimental hours.

Why not investigate Dollinger's facilities, experience, and personnel. Start by writing for brief composite catalog. It describes both standard and special Dollinger filters and their applications.

Write the Dollinger Corporation, 103 Centre Park, Rochester 3, N. Y.

PROTECTOMOTOR

STAYNEW FILTERS

DOLLINGER

SPECIALIZING IN DRY TYPE FILTERS FOR 35 YEARS

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

Circle 481 on Page 19

Circle 482 on Page 19→

Alcoa puts the metal where you want it

This "tree" represents six stages in the growth of an Alcoa® Impact. Actually the flow of metal occurs at a blink of the eye, but we've shown it in stages, outside the die for the sake of clarity. Furthermore, the finished piece (which you see on the bottom) has no practical use. It has, however, practical value. It starts the imagination fiddling with a host of design problems that involve the joining of several spokes to a central hub. For instance, it's not hard to imagine the spoke frame for an automobile steering wheel or horn ring sitting in its place. If that idea has you going, bear in mind that we can make round, oval, square and irregular parts the same way. Finished parts in many instances have greater *strength* than forgings —with *tolerances* down to plus or minus 0.005 in.—with a smooth, corrosion-resistant finish of about 125 microinches. A clear case of putting the metal where *you* want it.

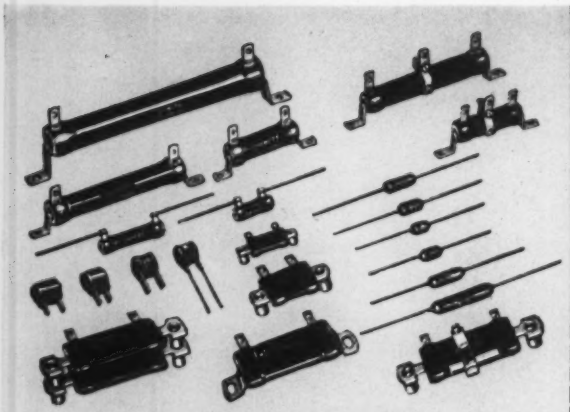
In impacts, as well as forgings, castings, extrusions and screw machine parts . . . Alcoa puts the metal where *you* want it. A call to Alcoa can mean fewer rejects or ingenious design solutions. Start now; write for Alcoa Up-To-Daters, a file of design tips on Alcoa Engineered Products. Aluminum Company of America, 928 Alcoa Building, Pittsburgh 19, Pa.

Your Guide to the Best in Aluminum Value

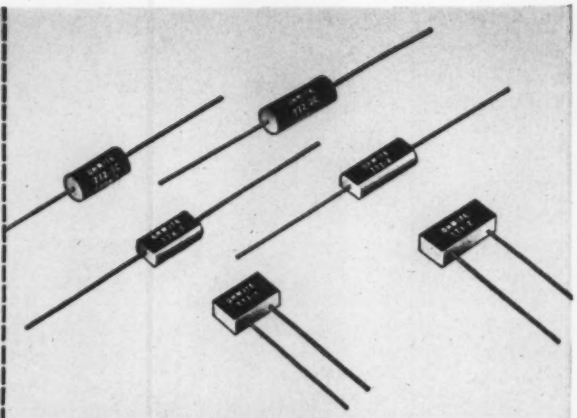
ALCOA ALUMINUM

Alcoa puts the metal where you want it — in castings, forgings, extrusions, screw machine parts and impacts.

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

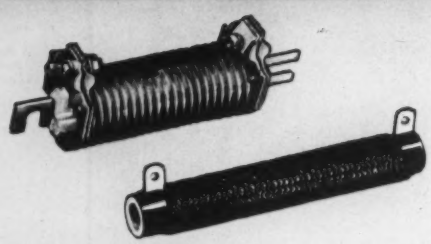


VITREOUS-ENAMELED RESISTORS Tremendous variety of types and sizes. Fixed, adjustable, tapped, noninductive, thin, and precision resistors available in a wide range of wattages and resistances. Also available to meet MIL-R-26C requirements.

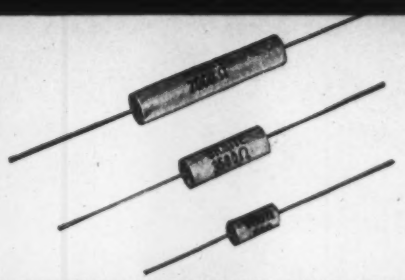


METAL FILM RESISTORS Riteohm® metal film precision resistors feature full ¼-watt rating at 150°C ambient; excellent high frequency characteristics; low temperature coefficient of resistance. Long-term load and shelf stability.

OHMITE INDUSTRY'S MOST COMPLETE LINE OF QUALITY WIRE-WOUND RESISTORS



POWER RESISTORS Power-type resistors for high-current, low-resistance applications. Vitreous-enameled, edge-wound, corrugated ribbon Corrib® units and open-type, edge-wound ribbon or round-wire Powr-Rib® units handle a wide range of power resistor needs. Available in fixed or adjustable "DIVIDOHM®" types.



MOLDED PRECISION WIRE-WOUND POWER RESISTORS Insulated units with Silicone-Type molded covering. Available in 3-, 5-, and 10-watt sizes. Tolerances: 0.1%, 0.25%, 0.5%, 1%, and 3%. Maximum resistance: 3-watt, 10,000 ohms; 5-watt, 25,000 ohms; 10-watt, 50,000 ohms.

OHMITE HAS EXACTLY THE RESISTOR YOU NEED

Ohmite offers the most complete line of high quality resistors on the market . . . fixed, adjustable, tapped, noninductive, and precision resistors in many sizes and types of terminals . . . in a wide range of wattages and resistances. All-welded construction. Ohmite application engineers will be pleased to help you in selecting the resistors for your job.

Write on company letterhead for Catalog 58.

NONINDUCTIVE

Tubular vitreous-enameled resistors with special winding. Dummy antennas consist of assemblies of several resistors. Watts, 5 to 1000; ohms, 1 to 5000.

SPECIAL VARIETIES

Ohmite can provide toroids, flat strips, plaques, special-sized tubes, or tubes with mixed terminals, etc. Watt ratings and resistances available as required.

OHMITE® Manufacturing Company
QUALITY COMPONENTS

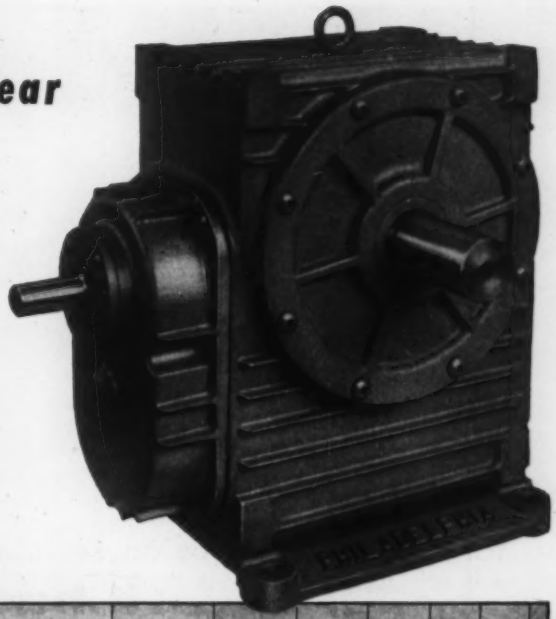
3618 Howard Street
Skokie, Illinois

RHEOSTATS RESISTORS RELAYS TAP SWITCHES TANTALUM CAPACITORS
R. F. CHOKES VARIABLE TRANSFORMERS DIODES

Circle 483 on Page 19

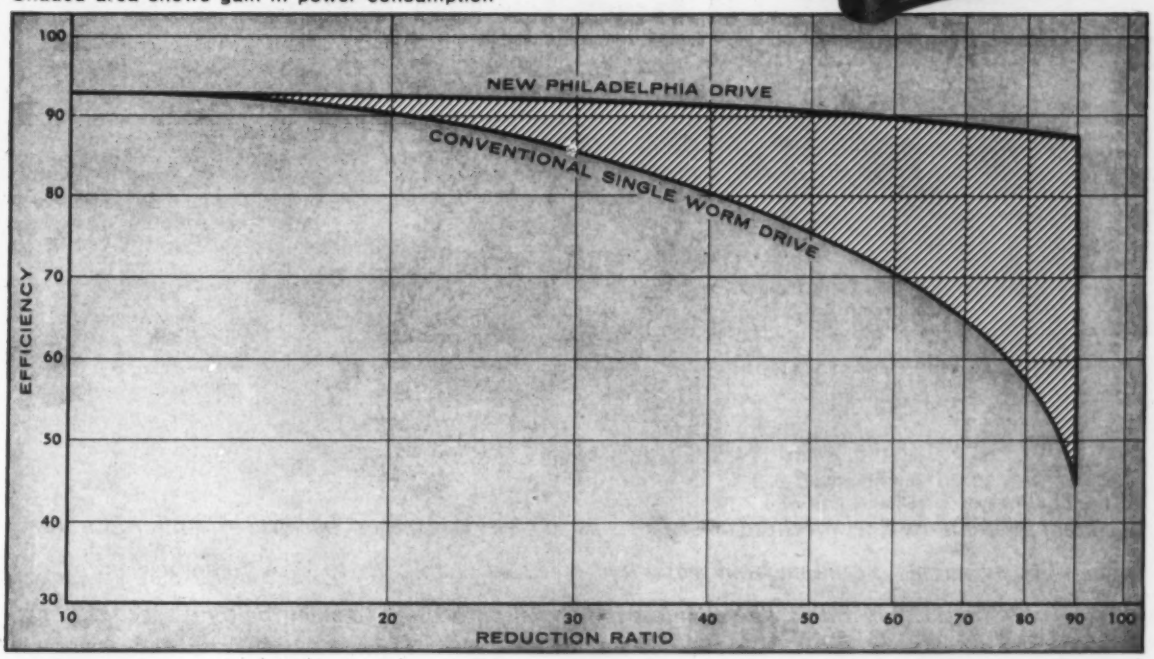
NEW...from Philadelphia Gear

HIGH EFFICIENCY WORM GEAR REDUCERS



Now you can get increased efficiency in worm gear drives —see curve. Helical attachments for double and triple reduction units combine the efficiency advantage of helical gearing with the high ratio advantage of worm gearing. You save on power consumption . . . high operating temperatures will never be a problem.

Shaded area shows gain in power consumption



New flexibility. One basic housing design plus standardized mounting bases, gearing, helical attachments and torque control attachments permit fast assembly from stock. You can get *any* drive arrangement, *any* mounting arrangement, in the exact size and ratio to meet your specific requirements. Torque control attachments for all sizes are available from stock for applications demanding overload protection.

New high capacity. This is not just a re-rated line. Improved tooth forms, precision ground alloy steel worms, special high strength bronze gears, sturdy housings, helical attachments with ground gearing . . . all mean higher capacity in less space. In fact, you get space savings to 50% . . . weight savings to 60%. Ratios from 5⅛: 1 to 1212: 1. Center distances from 3″ to 21″. Write for catalog data today.

philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

Erie Avenue and G Street • Philadelphia 34, Pennsylvania

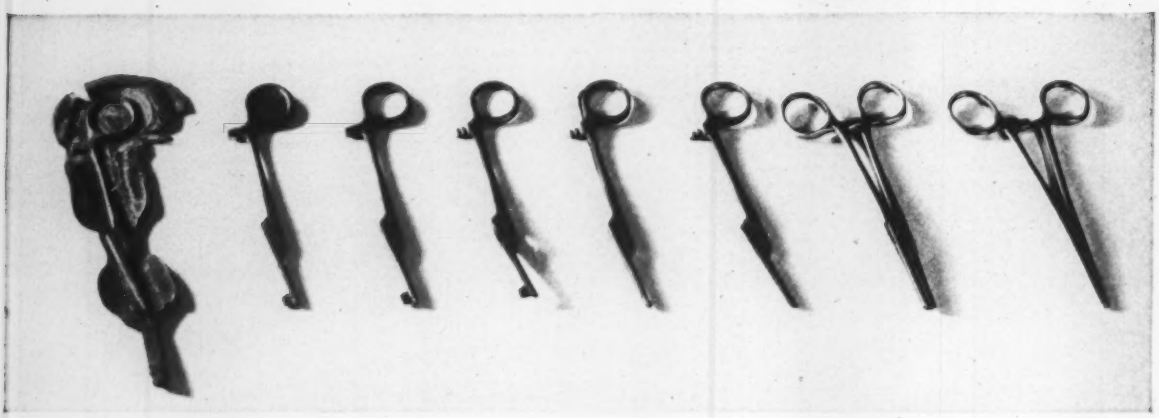
Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

Circle 484 on Page 19

for strength, corrosion resistance and high finish

...it had to be Stainless



All orders for stainless steel for these artery forceps specify "Carpenter" because of "uniformity from shipment to shipment". Freedom from seams and excellent machining to close tolerances are other reasons given by the fabricator. The stainless is specially processed to meet the rigid specifications. By specifying Carpenter you can take the pressure off both designer and fabricator. High temperatures and stress variations are no longer problems. We'll back up our success stories with technical data and on-the-job service. Call your Carpenter representative for information on the stainless you need. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter STEEL

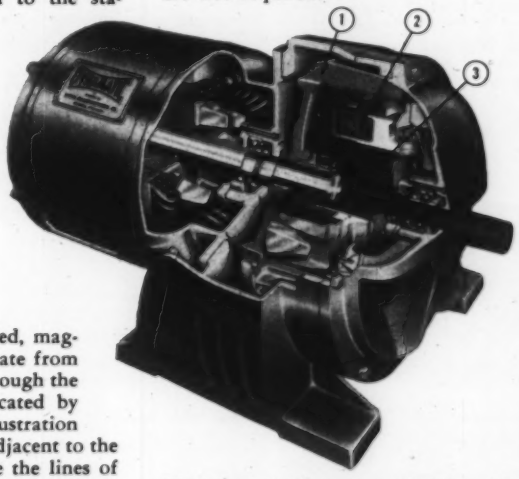
The Carpenter Steel Company
Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

HOW DYNAMATIC® Drives Provide Infinitely Adjustable Speed with AC Power

Dynamatic Ajusto-Spede® and Dynaspede® Drives operate from an alternating current power source and are infinitely adjustable from zero RPM to full output speed. Accurate control of output speed is obtained by varying the current in a single field coil.

Each Dynamatic Drive consists of a constant speed AC motor and an eddy-current coupling. Torque developed in the motor is transmitted through the coupling by electromagnetic attraction between its driving and driven members.

The driving member, or drum (1), is mounted on the end of the motor shaft and surrounds the rotor, or driven member (3). The drum is free to rotate independently of the rotor until current is applied to the stationary field coil (2).



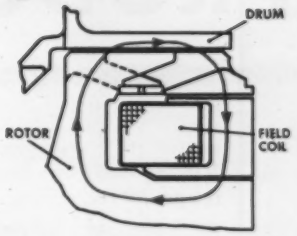
1. Input Drum Assembly
2. Stationary Field Assembly
3. Output Rotor Assembly

As the field coil is excited, magnetic lines of force emanate from the field coil and flow through the rotor and drum as indicated by arrows in cross-section illustration (A). Poles on the rotor adjacent to the smooth drum concentrate the lines of force into localized areas of "high flux" density in the drum's inner surface, shown in illustration (B). As the drum rotates about the rotor, these high flux areas sweep the inner surface of the drum, causing a variation of flux density that generates an eddy-current field in the drum's inner surface. Magnetic attraction between this eddy-current field and the rotor poles causes the rotor to rotate with the drum.

The torque transmitted from the drum to the rotor varies with the current applied to the field coil and with the "slip", or difference in speeds between the drum and rotor. Speed control with eddy-current equipment is obtained with a control system that adjusts field coil current to deliver the required torque at the desired slip.

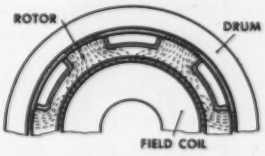
The control systems used with Dynamatic Eddy-Current Equipment operate on alternating current and require no special power source. Because of the low power required for field coil excitation, rectifying of field coil current is easily accomplished electronically. Expensive motor-generator sets are not required.

The control features available with Dynamatic Eddy-Current Equipment include constant speed regulation, acceleration control, torque regulation, cascading of multiple units, inching and threading, and numerous others as required by individual applications. Dynamatic Eddy-Current Equipment is ideally suited to automatic control.



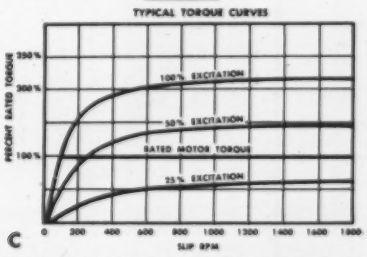
A

Flow of magnetic lines of force through rotor, drum, and stationary field.



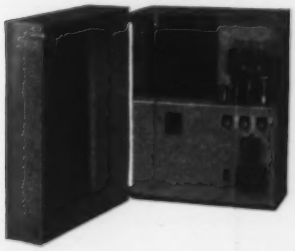
B

Concentration of magnetic lines of force by the rotor poles.



C

Typical torque curves show torque at various values of excitation. The horizontal line is rated motor torque.



D

The electronic control systems used with Dynamatic Eddy-Current Equipment do not require a special power source or motor-generator sets.

Send for your copy of Bulletin D-582 which gives detailed information on Dynamatic Eddy-Current Equipment.

EATON®

EATON MANUFACTURING COMPANY
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Circle 486 on Page 19

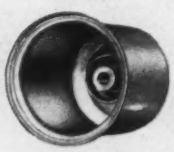
MUELLER BRASS CO. OFFERS 7 WAYS TO PRODUCE YOUR PART

Mueller Brass Co., because of its diversified manufacturing facilities that encompass a wide range of fabricating methods, is in the unique position of being able to offer you, the purchaser, an intelligent, unbiased analysis and recommendation of the best, most economical method by which your particular part can be produced. As the result of over 40 years' experience, the "Methods Analysis Department" has at its command complete knowledge of the advantages and limitations of each production process. After receiving detailed knowledge concerning the end use of the part, material specified, conditions under which it must operate and other pertinent factors, these analysis engineers make their recommendations. Every detail is considered. In many cases, methods analysis engineers recommend a simple design change that makes practical a much more economical method of production. This technical service, offered only by Mueller Brass Co., is given to each individual inquiry and is your assurance that you will get the best product at the best price . . . made the *one* best way . . . by Mueller Brass Co.

Send today for free technical literature on any one or all of the seven fabricating methods.

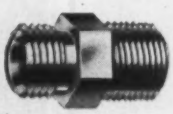
FORGINGS

Production equipment is available to produce press, hammer or cored forgings of any practical shape in sizes ranging from a few ounces to 150 lbs. In brass, bronze, aluminum and magnesium in 27 standard, as well as special, alloys.



COLD-PREST® IMPACT EXTRUSIONS

Mueller Brass Co. has complete machinery for producing Cold-Prest impact extrusions of aluminum, copper, brass, bronze and steel. Extrusions up to 28" in length are possible, depending on wall thickness and other design details. Parts can be designed having ribs, flutes, splines or bosses . . . with multiple wall diameters and with uniform or tapered wall sections.



SCREW MACHINE PRODUCTS

Mueller Brass Co. has one of the world's largest automatic screw machine departments fabricating both ferrous and non-ferrous custom parts. We can produce an infinite variety of shapes and sizes from ⅛" to 3¼" in wide range of free cutting and specialized alloys. Complete facilities for all secondary and finishing operations, as well.

POWDER METAL PARTS

Mueller Brass Co. can supply precision Sinteel® powder metal parts in wide range of sizes and metals at high production rate. Parts available from iron, brass and copper alloys. Parts may be ordered with such characteristics as self-lubrication, controlled porosity and good electrical and magnetic properties.

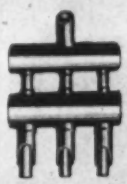
MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

MUELLER BRASS CO.

...and our methods analysis service helps you determine which is the best ...and most economical method

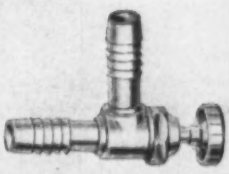
SAND CASTINGS

We specialize in the production of pressure-tight red brass castings. We utilize both metal match plate and wood patterns. Facilities include tool room and pattern shop, electric melting furnaces, high capacity core room and both bench and floor molding equipment to handle wide range of sizes.



FORMED COPPER TUBE

Mueller Brass Co. has modern facilities for forming seamless copper tube into a multitude of shapes. Forming methods used include bending, spinning, expanding or swedging, upsetting, flaring, flattening, beading and grooving, drilling and piercing, machining and joining. Formed copper tube coils are also available as single, double, spiral and serpentine shapes.



PLASTIC INJECTION MOLDING

Injection molding of plastic parts is still another process offered by the Mueller Brass Co. Parts are molded from such plastics as—nylon, polyethylenes, polyvinyl chloride, styrenes, linear acetal, chlorinated polyether, polycarbonates or polypropylene, dependent on part application.

MAN FROM MUELLER BRASS CO.

Since only Mueller Brass Co. can produce your part by all the methods, only the Man From Mueller Brass Co. can give sound advice on the one best method of production. Over 40 years of research, engineering, manufacturing and marketing experience stands behind him. When you are specifying and purchasing fabricated metal parts, call in the MAN FROM MUELLER BRASS CO.

271

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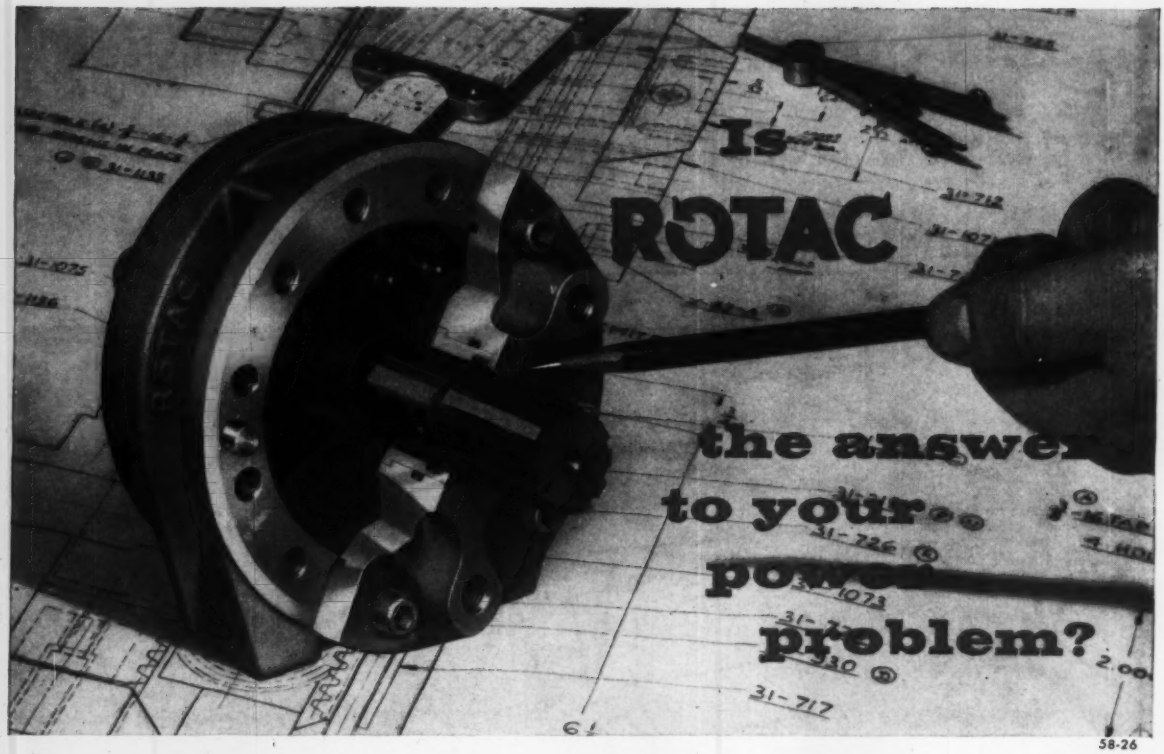

58-26

Rōtac torque actuators are simple, compact—provide positively controlled power for any movement from turning watch parts to tipping railroad cars

RŌTAC Rotary Torque Actuators consist of a cylindrical chamber containing a stationary barrier or shoe, and a central shaft with a fixed vane. With fluid or pneumatic pressure applied to either side of the vane, rotary movement in the opposite direction is obtained.

There is no complex linkage, no plunger action: RŌTAC's few moving parts are completely sealed from dirt and natural elements. Patented O-rings are used around vane, shoe and end caps.

RŌTAC Torque Actuators can be mounted easily—vertically, horizontally or at any angle—with the housing held stationary, or with the body rotating around the shaft.

To simplify design problems, for versatility in extended applications, specify RŌTAC Actuators for powerful, easily controlled rotary motion in compact form.

FREE DESIGN DATA BOOK—20 PAGES

Contains everything you'll want to know about RŌTAC — Installation details • Dimensions • Torque ratings • Helpful ideas for using RŌTAC Actuators in your operations.

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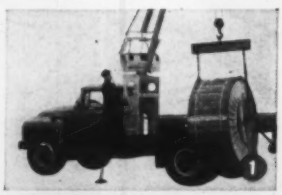
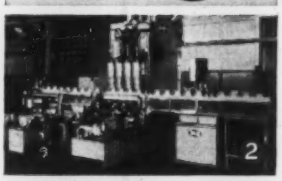
GREENVILLE PLANT, GREENVILLE, OHIO

EX-CELL-O PRECISION PRODUCTS INCLUDE: MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • TORQUE ACTUATORS • DAIRY EQUIPMENT





Just 4 of the hundreds of recent applications

1. MOBILE EQUIPMENT—A compact RŌTAC Actuator swings truck crane boom in 280° travel arc; it's controlled by a 4-way valve.

2. MACHINE TOOLS—Automation machine for boring, grooving piston wrist pin holes uses RŌTAC Actuator to orient arbors for hole alignment.

3. FOUNDRY MACHINERY—RŌTAC Actuators supply motive power for turnover of the core-box on semi-automatic shell core blower.

4. PAPER MACHINERY—Collector roll is actuated by a Model HN-63-1V RŌTAC Actuator which unloads material after slitting operation.

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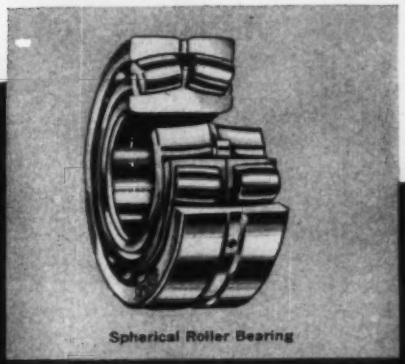
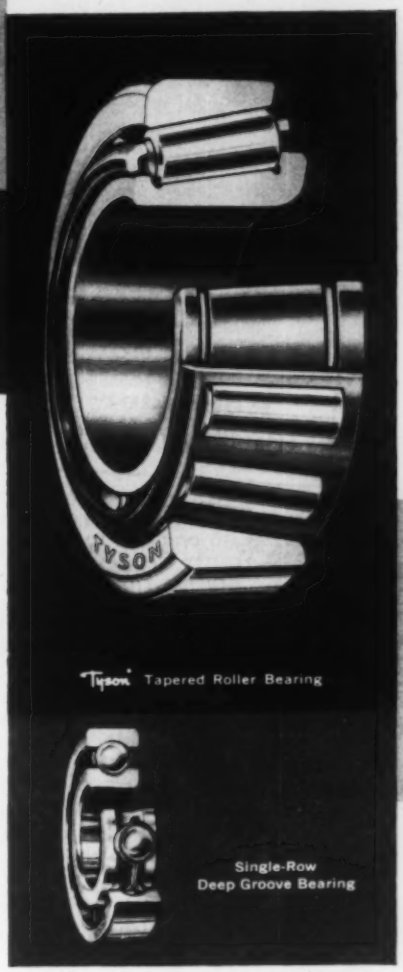
We make so many sizes... your "specials" could be our "standards"

Angular Contact Bearing


Spherical Roller Bearing

Spherical Roller Thrust Bearing



"Tyson" Tapered Roller Bearing

Cylindrical Roller Bearing

Single-Row Deep Groove Bearing

We regularly produce all of the bearings shown here in a tremendous variety of bores, outside diameters, and widths.

Take just the Tyson tapered roller bearing, for example. We make nearly 1,000 sizes of the single-row, straight bore type alone! Bore sizes range from five-eighths of an inch right up to a precise fourteen inches. And these figures don't include the many other sizes available in our double- and four-row types.

Yet they are all standard SKF *bearings,* promptly available in large quantities at competitive prices.

So, why not get full details on the most complete line in the business? Any of our twenty-five sales offices can quote you facts and figures. Just call the one near you.

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Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

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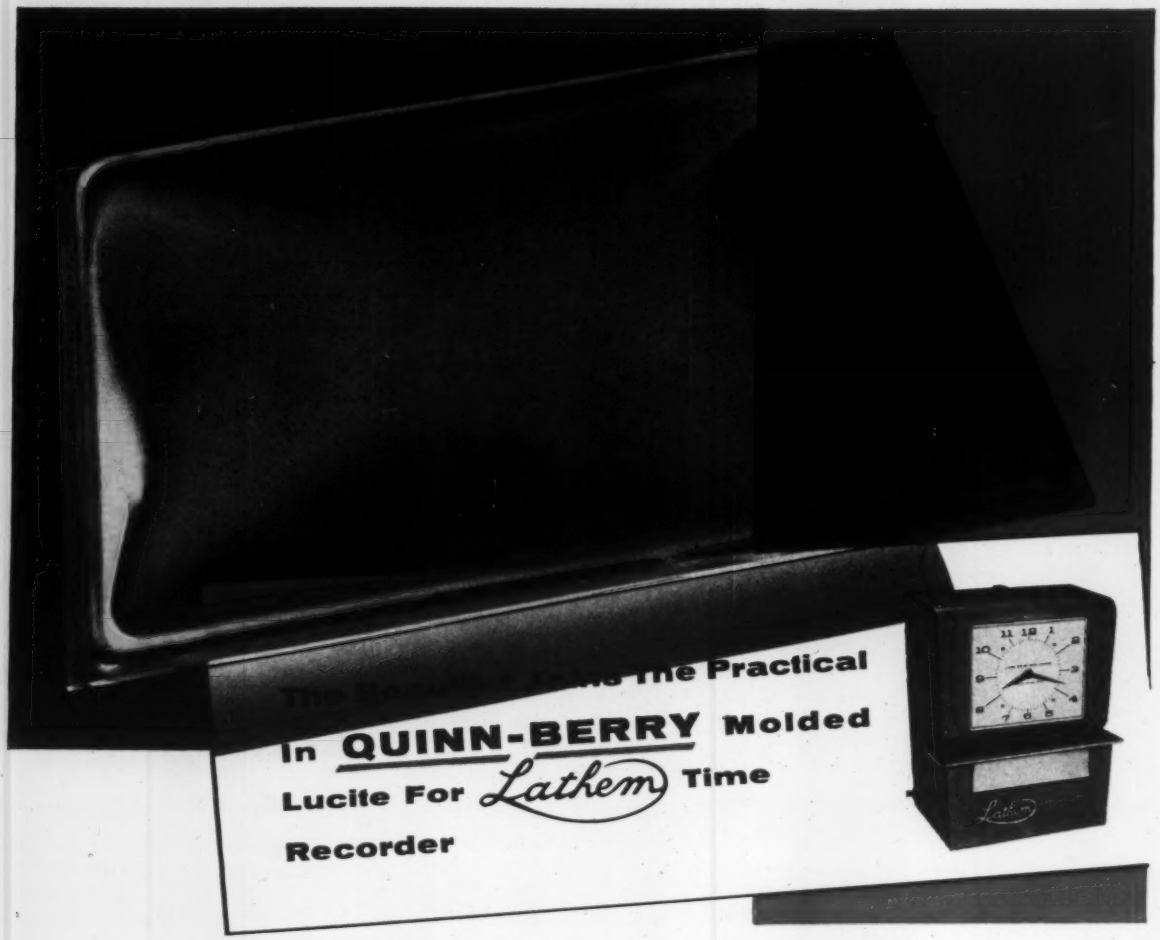

... the Practical In QUINN-BERRY Molded Lucite For Lathem Time Recorder

Crystal clear beauty is joined with practical toughness to give greater face visibility to the Lathem Time Recorder . . . DuPont Lucite Crystal molded by Quinn-Berry. Here is what Mr. L. P. Lathem, Jr. says:

"It was the Quinn-Berry Crystal which enabled us to design the new Lathem Time Recorder to give it unprecedented beauty.

"For example, we were able to get a curved Quinn-Berry Crystal which would easily mount in the case of the Lathem Recorder without the need of a bezel. This allowed us to design the recorder so that the face is flush to the clock case, and stands out even more, because of the effect of the curved crystal.

"In addition, this crystal causes no distortion of the face numerals, is unbreakable, resists scratches and discoloration, and does not rattle . . .

"All of us at the factory, as well as our Lathem dealers, have praised the modern appearance of the new Lathem Recorder which owes so much of its design to the qualties of the Quinn-Berry Crystal."

It is quite possible that we can help you with your parts requirements. Consult with us.

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CUSTOM MOLDERS OF ALL TYPES OF THERMOPLASTICS

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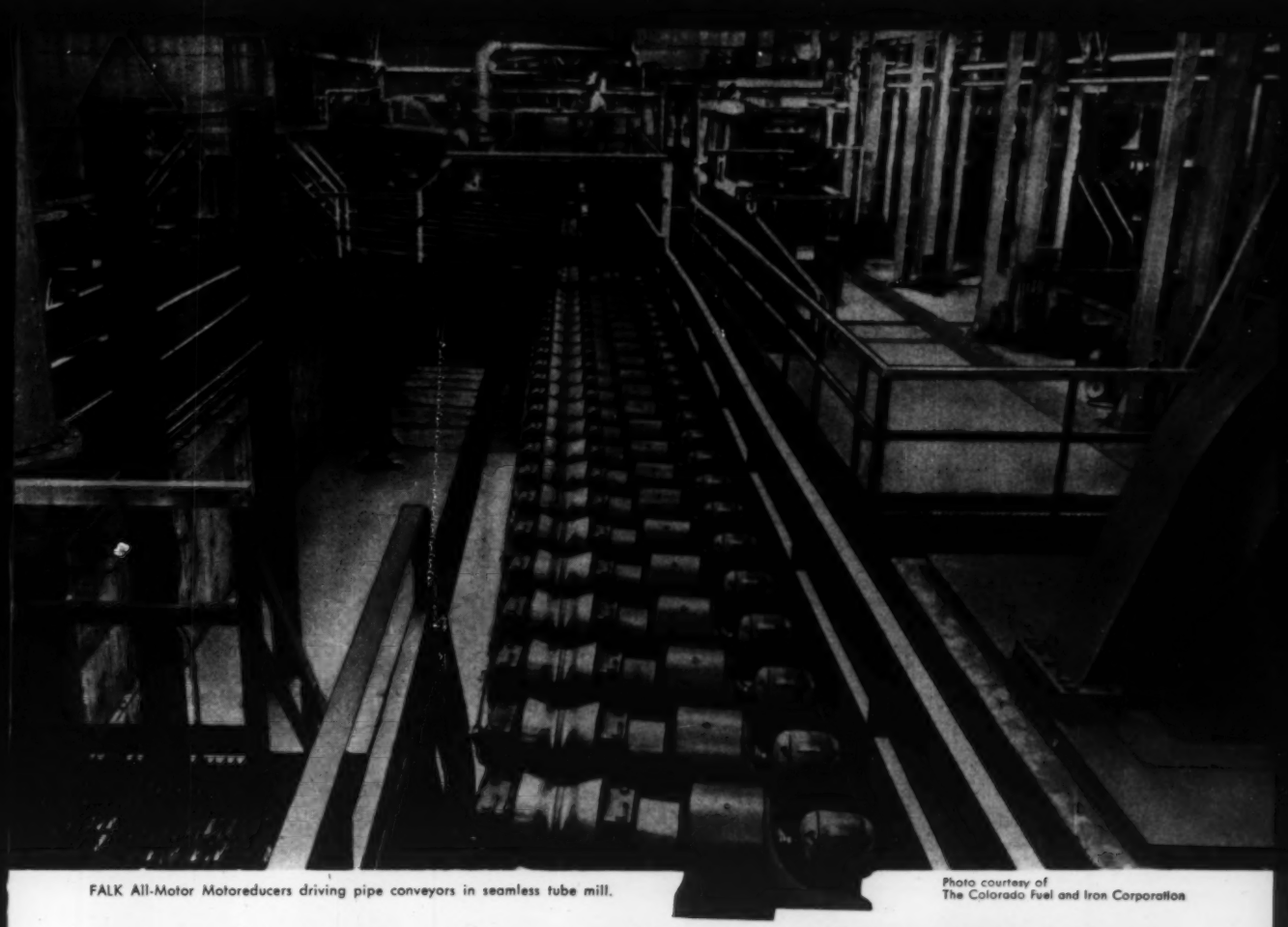

FALK All-Motor Motoreducers driving pipe conveyors in seamless tube mill.

Photo courtesy of
The Colorado Fuel and Iron Corporation

You get these "extras" when you buy FALK *all-steel* Motoreducers

1. **Freedom from damaged housings.** The exclusive FALK *all-steel* construction gives full protection from cracked housings or torn-off feet...plus twice the ability of cast iron to maintain vital alignment.
2. **12-15% reserve load-carrying capacity** in the gears, by AGMA standards. The extra-depth, high pressure angle helical gears are another FALK exclusive ...they assure better operation and longer gear life.
3. **Highest known gear efficiency**—98½% per gear train under full load! This means maximum productive work for your power dollar.
4. **Longer service life**...advanced FALK design makes it possible to machine both bores for each shaft assembly at one time, thus eliminating possible accumulation of tolerances that occurs when individually machined parts are assembled. The result—better alignment of revolving elements that permits units to transmit rated capacity longer.
5. **Standard units to fit your needs.** Integral and All-Motor® Motoreducers are available in horizontal, vertical and right angle types...a type for every use.

Units are available up to 75 hp; output speeds from 780 rpm down to 1.2 rpm. Prompt delivery from factory, warehouse or distributor stocks.
Ask your FALK Representative or Authorized FALK Distributor for *Bulletin 3100.*

THE FALK CORPORATION, MILWAUKEE 1, WIS.

MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

Representatives and Distributors in most principal cities

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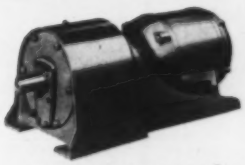
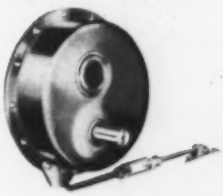


THE FALK ALL-MOTOR® MOTOREDUCER
the original All-Motor unit

(Shown) Horizontal concentric model. Also available in right angle and vertical types.

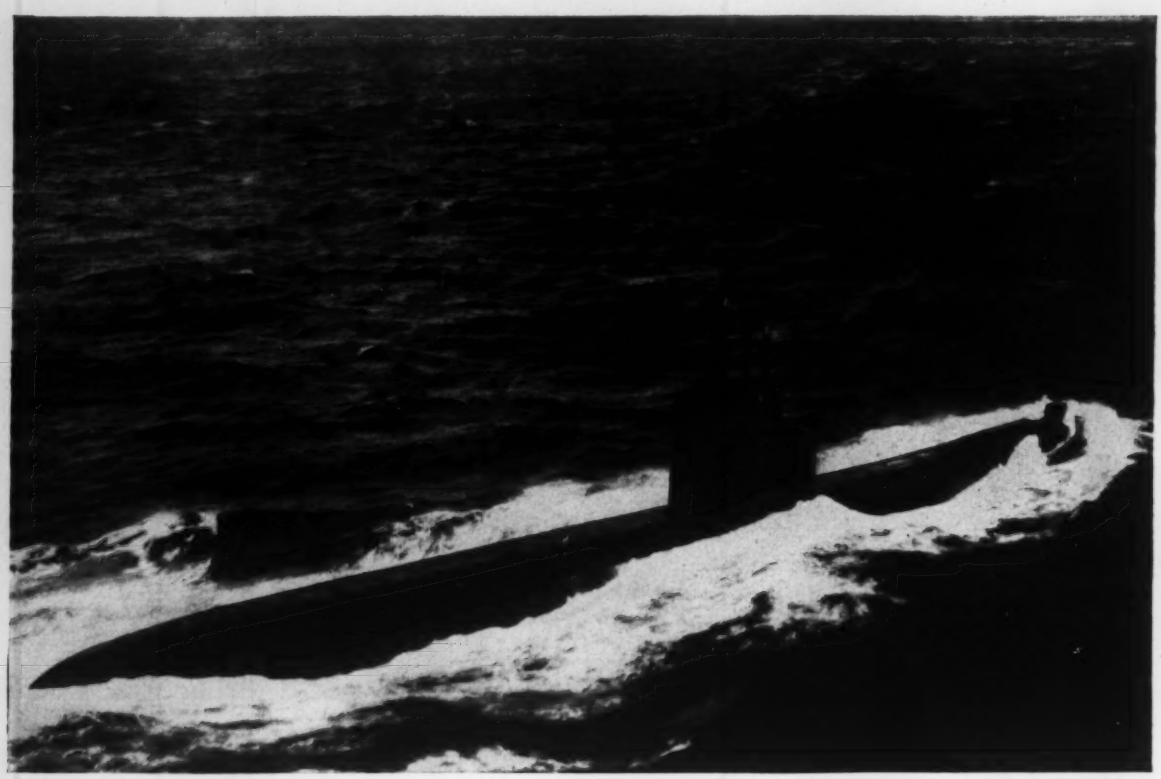


THE ALL-STEEL FALK® SHAFT MOUNTED DRIVE

Proved best for the countless industrial applications where a reducing unit mounting directly on shaft of the driven machine is indicated.

Units from 1/2 to 50 hp. Ratios —4:1, 14:1 or 24:1. Torque capacity up to 41,000 lb-in (in standard units). Prompt shipment from stock. For details, ask for *Bulletin 7100.*

ELECTROLIZED for Reliability...



Official U.S. Navy Photo

. . . maximum wear life, minimum friction and increased corrosion resistance imparted to critical wear parts in U.S. Nuclear Submarine Fleet

Reliability of mechanisms in the nuclear submarines Nautilus, Skate, and Seawolf is heightened by specification of Electrolizing on more than 50 different critical wear parts.

Exhaustive testing prior to specification established that Electrolizing provides superior anti-seizure characteristics . . . an extremely low coefficient of friction . . . remarkable wear resistance . . . and beneficial resistance to corrosion.

Wherever reliability is a primary consideration, Electrolizing is the answer. The Electrolizing deposit is an extremely hard (70-72Rc), dense, nonmagnetic alloy which can be applied to both ferrous and nonferrous metal surfaces. It has no adverse effect on the basis metal . . . can be held to a tolerance of .000025" . . . cannot be separated from the basis metal by peeling, chipping, or flaking . . . does not "build up" or cause nodulation on sharp edges . . . and can be held to two light bands flatness.

You can test Electrolizing at no cost and without obligation. Simply submit sample parts, a letter outlining the problem, and a drawing indicating the critical area. These parts will be Electrolized without charge and returned to you for test. (Cutting tools, dies, and molds excluded from this offer.)

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Note—Commercial and Military Packaging Engineers:

LINK-LOCK

...Is the rugged answer to your exacting container closure problems

LINK-LOCK plays an important role in the design of this container

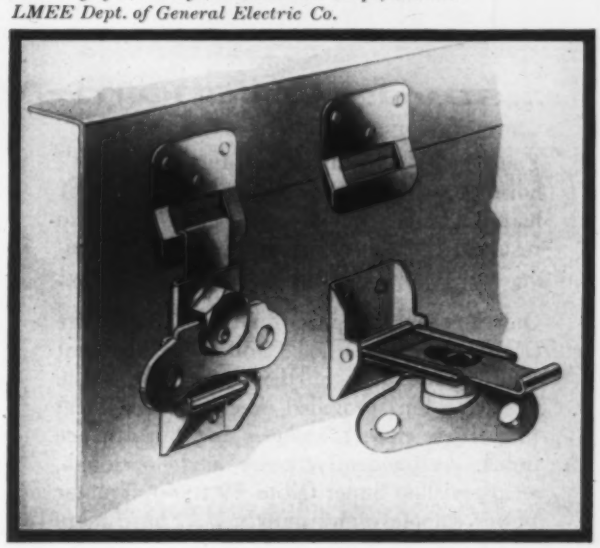
Courtesy of Pressurform Container Corp., and the LMEE Dept. of General Electric Co.

Simmons' LINK-LOCK provides pressure-tight, impact-resistant closure, plus quick closing and opening, on this reinforced fibrous plastic product made by the new automatic pre-form process developed by Pressurform Container Corp. The two-section container will be used by the Light Military Electronic Equipment Dept. of General Electric Company for shipping airborne radar jamming units to the Air Force.

Of prime importance are the container's lightness, strength, rust- and mildew-resistance, ability to withstand high pressures without distortion, ease of locking and opening, and low cost.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- High closing pressure with light operating torque... insures pressure-tight seals where required.
- Impact and shock resistant (positive-locking).
- Compact design...lays flat against case even when unlocked.
- Available in 3 sizes, for heavy, medium, and light duty.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.



Also available! Spring-Loaded LINK-LOCK... ideal for less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For full information and specifications, send for LINK-LOCK DATA SHEETS today. Samples and engineering service available upon request.

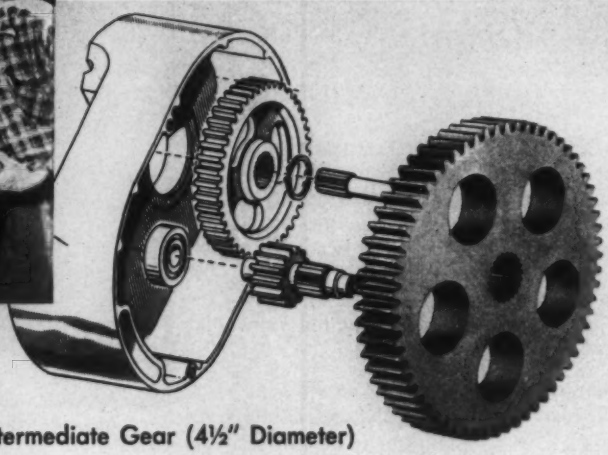
SIMMONS
FASTENER CORPORATION
1756 North Broadway, Albany 1, New York

QUICK-LOCK SPRING-LOCK ROTO-LOCK LINK-LOCK DUAL-LOCK

See our 8-page Catalog In Sweet's Production Design File

OILITE

GEAR GIVES POSITIVE "LIFT" IN POWER HOIST DESIGN



Super Oilite #9 Intermediate Gear (4½" Diameter)

...saves Chisholm-Moore 53¢ per unit

You can be sure this heavy-duty "Lodestar" hoist is a rugged performer capable of handling loads quickly, efficiently . . . the result of CM's 70 years experience in designing and manufacturing hoists for industry!

Only top quality parts qualify. That's why CM engineers specified "Oilite"® for the vital intermediate gear of the train. The Oilite Precision Part provided excellent mechanical properties, close tolerances and fine surface finish. Consequently, gears made of tough, wear-resistant Super Oilite #9 transmit motor power smoothly and quietly . . . have more than enough mechanical strength to assure long, trouble-free life.

Moreover, the Oilite gear is produced as a finished part requiring no machining . . . saving CM *53c on every gear used!* Chrysler-engineered Oilite Precision Parts are obtainable in many metals and alloys to give desired mechanical properties. Savings up to 55% or more are common for parts produced in volume.

Contact your local Oilite Engineer for possible savings on your parts. Look for him in the Yellow Pages under "Bearings—Oilite" or write Dept. S-3.

® Only Chrysler Makes Oilite

PM MEMBER

SINCE 1929

A CHRYSLER OILITE PRODUCT

the most trusted name in powder metallurgy!

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SELF-LUBRICATING BEARINGS • PRECISION PARTS • METAL FILTERS • FRICTION UNITS

Circle 494 on Page 19

Air seals
Bearing seals
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Carrying cases
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Fuel containers
Fuel pump diaphragms
Gaskets
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engineers specify Reevecote

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. . . the one complete source of engineered industrial coated fabrics

Whether it's resistance to high temperature, oil or abrasion—or flexibility at low temperature or room temperature, there's a Reevecote designed to do your job.

96 different Reevecote styles are in stock at all times! Constructed under rigid quality-control standards, each is guaranteed to meet the exact listed specifications.

In addition, full research and development facilities are available for new applications, backed by the skills and knowledge of fabrics and coatings that only the combination of Reeves and Vulcan can supply. Whatever your requirements, specify Reevecote and be sure.

Write for a copy of the new Reevecote catalog —it's just off the press.

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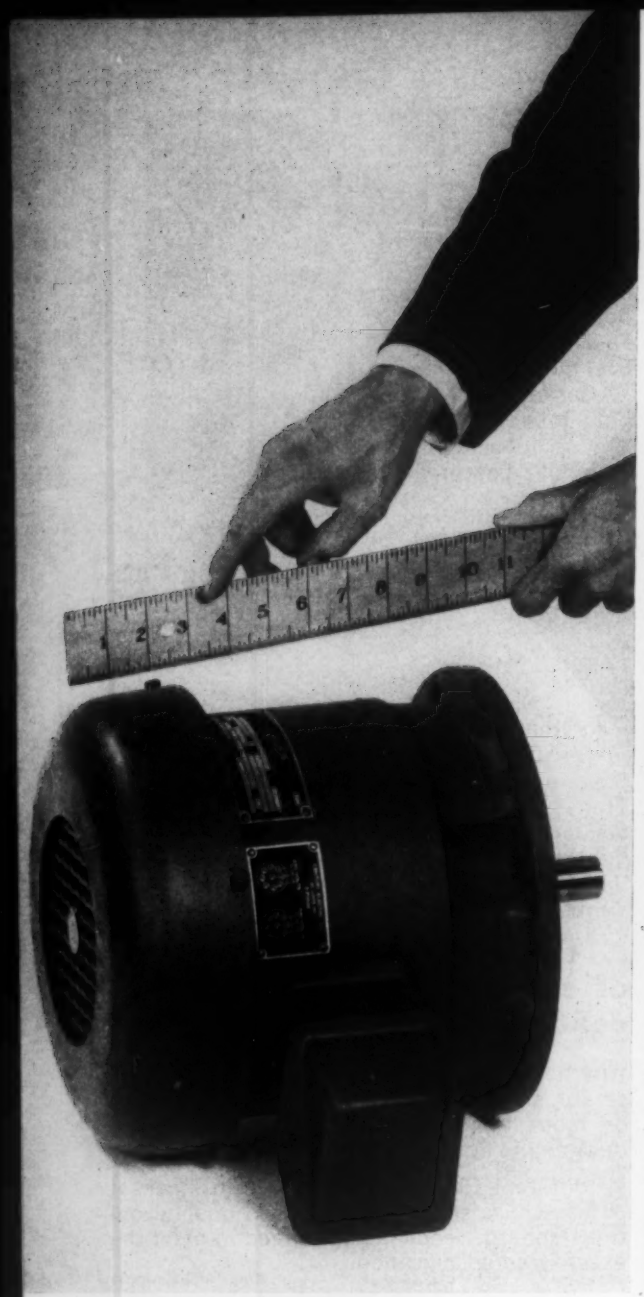
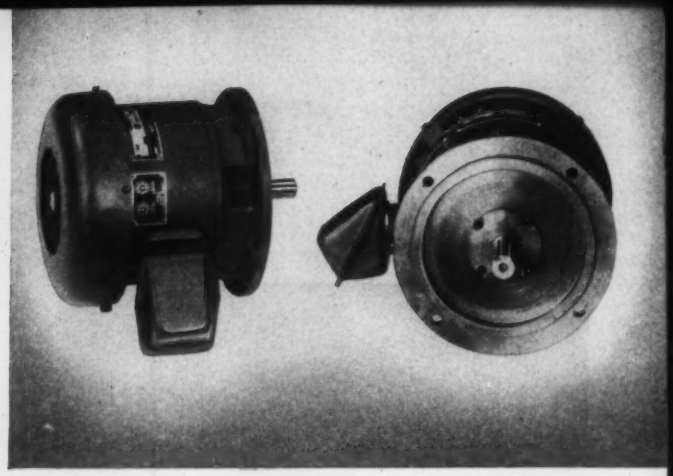
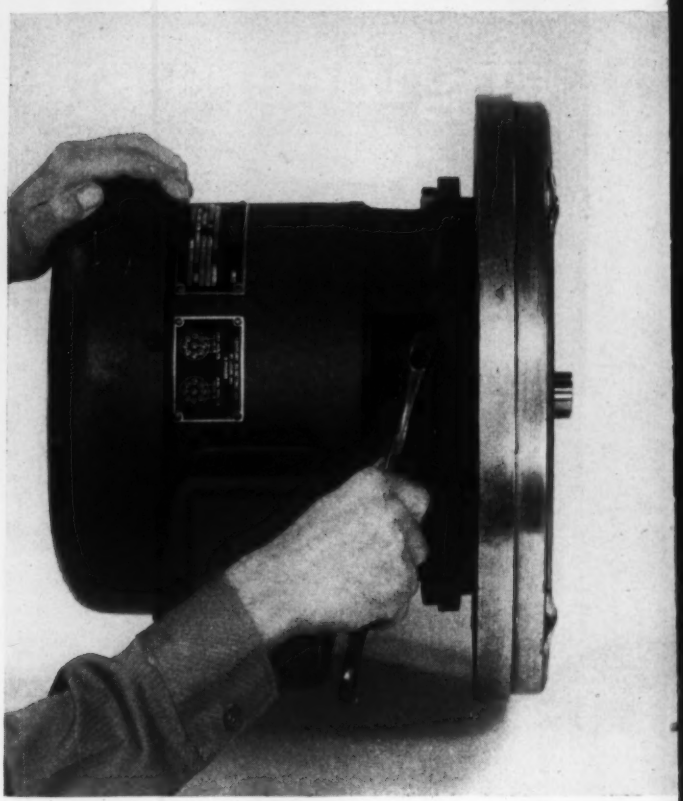


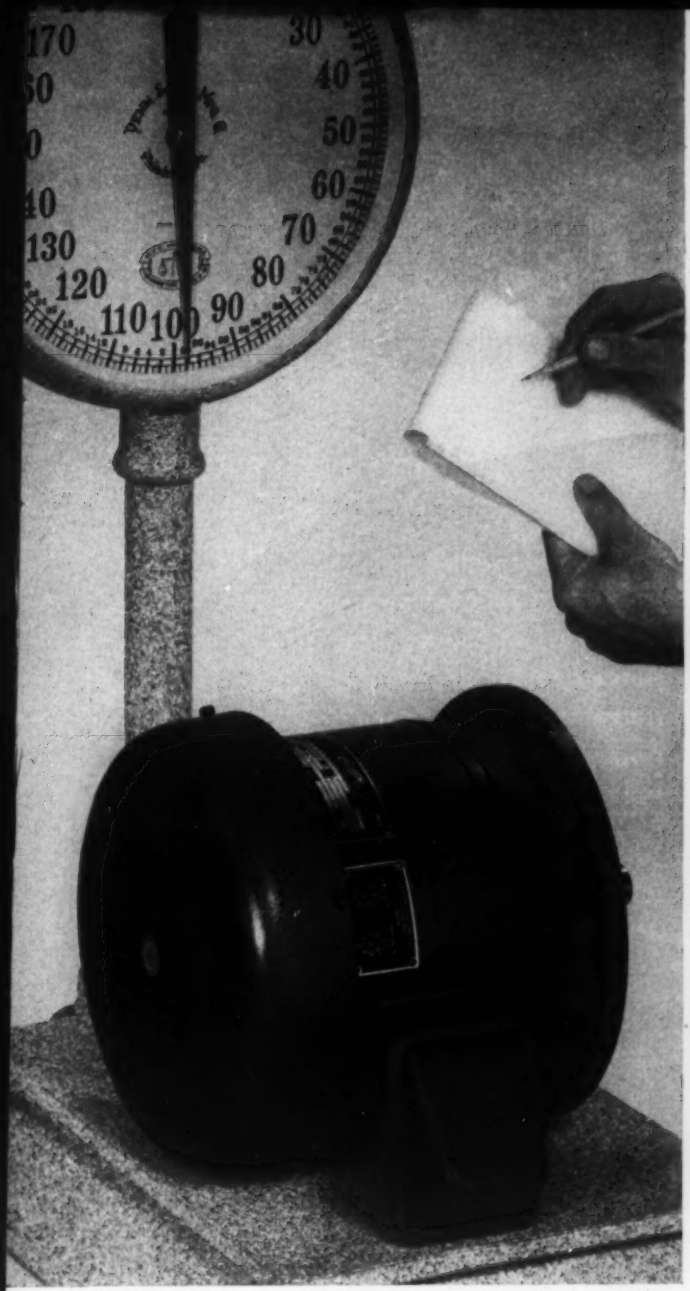




It's smaller. . . easy to mount . .

This is *not* simply a rerated motor. The Century Electric short motor is a standard motor available in ratings up to 15 hp, but . . . it has been redesigned to cut down length as much as four inches. It is designed to save space and weight for application on machine tools, roof ventilators, pumps, centrifuges and many other types of equipment.

Easy to mount: You can use this motor in place of any end-mounted motor because it has a standard flange. It can also be mounted horizontally, vertically or at any angle. Its small size means it can be mounted almost anywhere on equipment.



. lighter . . . *The Century Electric short motor*

Variety of applications: The short motor gives dependable performance on applications requiring frequent start-stop operation. You can get it in totally enclosed or open frames. And it has the same quality features and high standards of all of Century Electric's complete line—up to 400 hp.

More than a motor: This motor is the result of a continuing search for ways to meet industry's needs. Another reason why you get *more* than a motor from Century Electric.

For more details contact your nearest Century Electric Sales Office or Authorized Distributor.

CENTURY ELECTRIC COMPANY

St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Circle 496 on Page 19

Century 58-14

6 alloys=95% of today's engine bearing requirements

Steel backs, lined with:
FEDERALOY A-200 Aluminum alloy
FEDERALOY H-24 Copper alloy
FEDERALOY H-35 Copper alloy
FEDERALOY H-50 Copper alloy
FEDERALOY B-100 Tin-base babbitt
FEDERALOY L-200 Lead-base babbitt

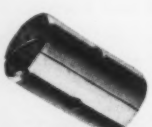
This group of sleeve bearing alloys permits the engineer to design for all conventional commercial applications. At the same time, he can meet his performance and cost requirements.

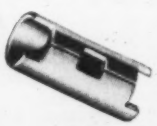
Each of these alloys has been thoroughly proved and accepted by leading engine builders. Our production of millions of sleeve bearings each year assures you of the highest quality, efficiency and economy. Complete engineering service. A copy of the "Sleeve Bearing Design Guide" will be sent free on request. Address:

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

Spacer Tubes


Bimetal Bushings


Plain Bushings

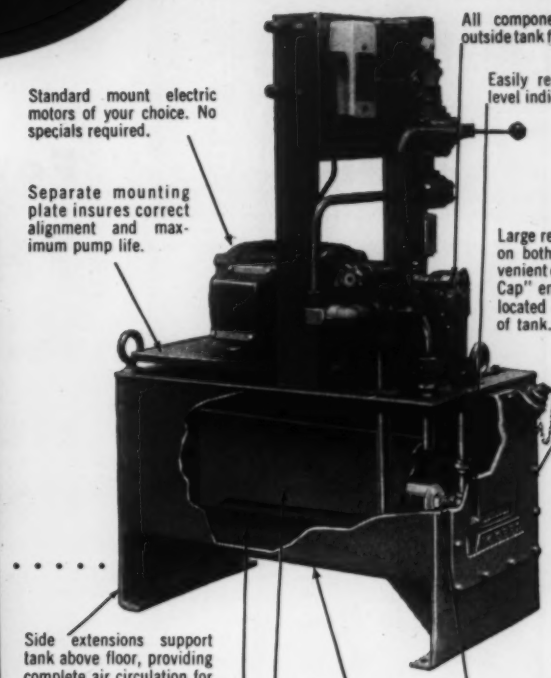
Precision Thrust Washers

FEDERAL Mogul SINCE 1899

Circle 497 on Page 19

You save money and time applying Hydraulics when you buy the . . .

VICKERS *package . . . . . instead of parts*

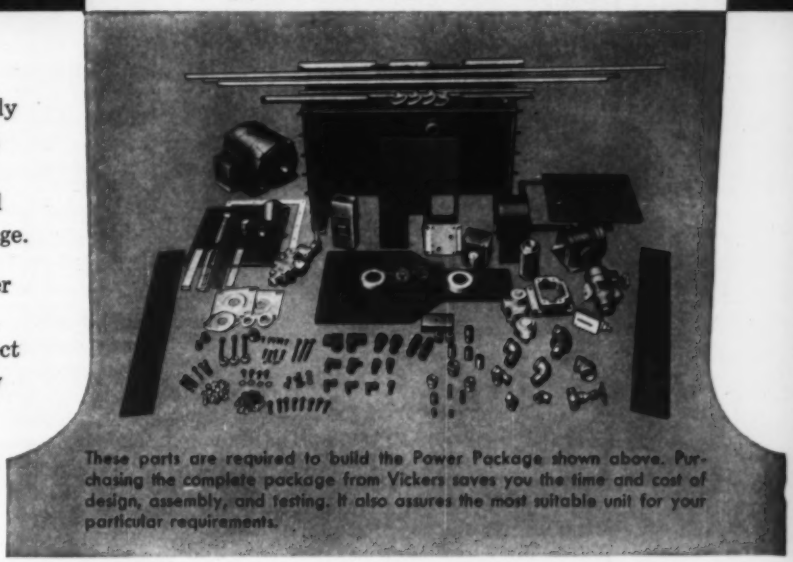

All components mounted outside tank for easy access.
Easily read accurate fluid level indicator.
Standard mount electric motors of your choice. No specials required.
Separate mounting plate insures correct alignment and maximum pump life.
Large removable covers on both ends for convenient cleaning. "Filler Cap" end cover can be located at either end of tank.
Side extensions support tank above floor, providing complete air circulation for maximum heat rejection.
Corrosion protection—internal tank surfaces sand-blasted and specially painted.
Inlet strainers can be removed and cleaned without disconnecting components or pressure piping.
New baffle plate improves fluid circulation.
Easy accessibility to drain plug.

Vickers Custom Built Power Package . . . complete . . . factory pretested . . . ready to connect and operate.

You save time and expense of design, layout, multiple purchasing, and assembly when you buy the Vickers package. You are assured of component compatibility and Vickers undivided responsibility and guarantee for the entire hydraulic package.

A Vickers Custom Built Hydraulic Power Package is a "complete unit" . . . factory pretested, ready for you to connect and operate. Designed and professionally built to your specifications.

Call in a Vickers Application Engineer or write for Bulletin 5001B.



These parts are required to build the Power Package shown above. Purchasing the complete package from Vickers saves you the time and cost of design, assembly, and testing. It also assures the most suitable unit for your particular requirements.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: ATLANTA • CHICAGO* • CINCINNATI • CLEVELAND • DETROIT* • GRAND RAPIDS • HOUSTON • INDIANAPOLIS • LOS ANGELES AREA (El Segundo)* • MILWAUKEE • NEW YORK AREA (Springfield, N.J.)* • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE* • ST. LOUIS • WORCESTER • Factories also in: Australia, England, Japan and Germany • In Canada: Vickers-Sperry of Canada, Ltd., Toronto,* Montreal and Vancouver
Field Service Headquarters Underlined. Whse. Stock & Repair Branches*.

8155

Circle 498 on Page 19

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

CHOICE OF BUILT-IN VALVES GIVES CONTROL FLEXIBILITY

SINGLE AIR CONNECTION SIMPLIFIES INSTALLATION

RUGGED CONSTRUCTION ASSURES LONG LIFE

125 BELLOWS SALES AND SERVICE FIELD ENGINEERS

■ There are one or more Bellows Field Engineers in every industrial area of the United States and Canada. They will be happy to work with you in applying "Controlled-Air-Power" to your machine designs. They are listed in their local phone directories under "The Bellows Co."

758-B

Four reasons why THE BELLOWS AIR MOTOR stands first with design engineers

In designing for air cylinder operation the engineer wants first of all sure, positive control, easily interlocked to related machine movements. **He has it in The Bellows Air Motor.**

He wants simple installation, uncomplicated by cumbersome piping. **He has it in The Bellows Air Motor.**

He wants rugged construction — an air cylinder that will stand up day in and day out with minimum requirements for service and repairs. **He has it in The Bellows Air Motor.**

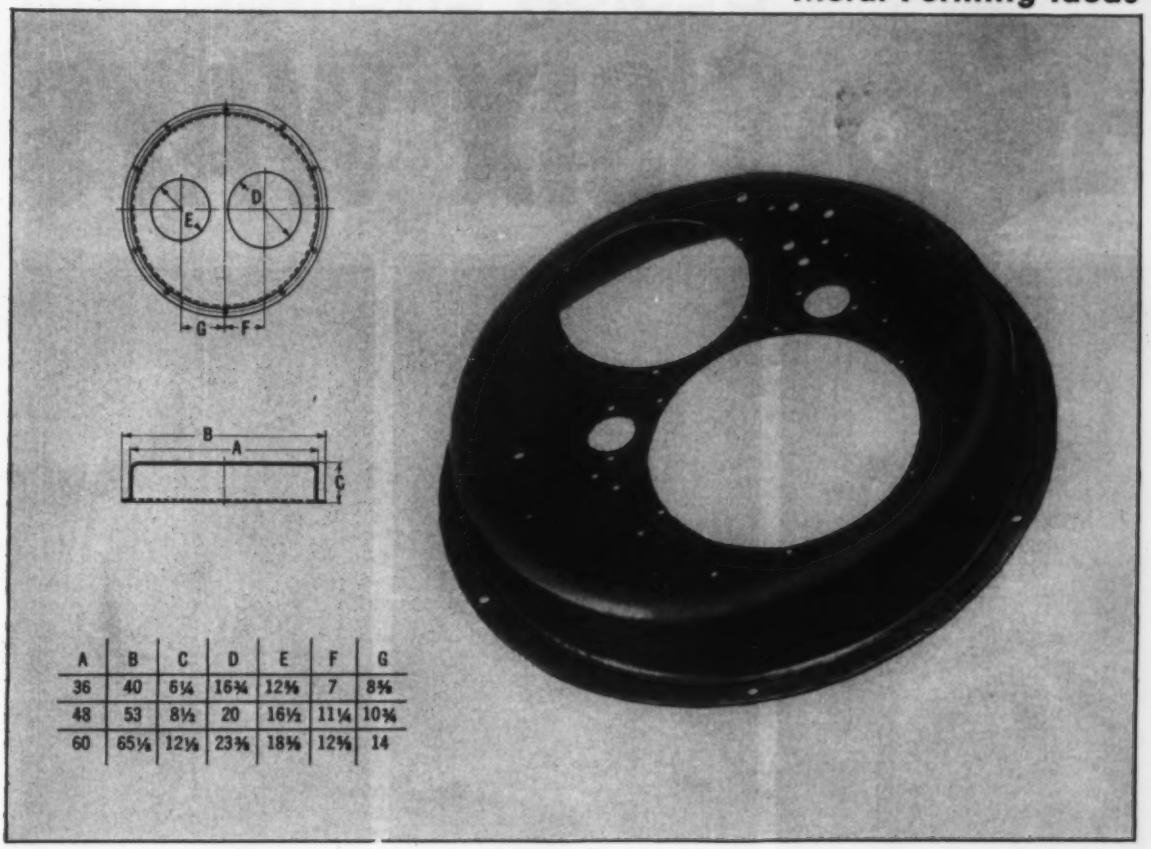
But he also wants the knowledge, if service should ever be needed, that it is quickly available wherever his machine may go. **He has it in The Bellows Air Motor.**

The Bellows Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

AKRON 9, OHIO

This free booklet offers interesting data for the design engineer. Write for it today. Address Dept. MD-359. Ask for Bulletin BM-25. The Bellows Co., Akron 9, Ohio. In Canada: Bellows Pneumatic Devices of Canada, Ltd.



A	B	C	D	E	F	G
36	40	6¼	16¾	12⅝	7	8⅛
48	53	8½	20	16½	11¼	10¾
60	65⅛	12⅛	23⅛	18⅛	12⅛	14

Cuts costly operations on component part

One operation pin points 63 holes in dish-stamped 60" diameter boiler door—completely eliminates accumulative error

Exact dimensional sizing and accurate placement of all holes—eliminating any chance of accumulative error—is a primary requirement in the dished boiler doors being produced for the Cleaver-Brooks Company.

Equally important is close adherence to a tolerance of plus or minus 1/16" on diameter, and flat across the flange within 1/16"—even after the gang-piercing operation in order to guarantee perfect fit and draft-free closing seal.

Gang-piercing of the required holes in the Cleaver-Brooks boiler doors—involving a one-hit operation—insured identical dimensional and location accuracy of all holes at lower cost.

When other fabricating methods proved unsatisfactory and too expensive, Cleaver-Brooks turned to COMMERCIAL. Dies for the stampings were designed and produced by COMMERCIAL and the boiler doors are now turned out on a regular production basis on a 2000 ton mechanical press with an 8 x 16 ft. bed and a 30 in. stroke.

The close dimensional tolerances of the multiple holes in the boiler doors eliminate the need for further reaming. The exact spacing of all holes, which is completely free of any accumulative error, makes it possible to mount boiler accessories directly to the boiler doors without any assembly time lag. Also eliminated, thanks to gang-piercing, is the need for any flat surface facing before accessories can be mounted.

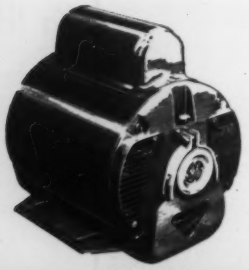
Other costly and time consuming operations formerly required, such as flame cutting, rolling rings, machining edges, welding, weld inspection, cutting holes, etc., not to mention the use of many expensive fixtures, have now all been eliminated by the heavy stampings produced by COMMERCIAL.

The greater accuracy afforded by the stamping method obviously leads to many important savings in the complete production operation—invariably means lower product cost. Because accuracy in stampings is identical—almost automatic—it involves no time lag, requires less man and machine hours to gain. At the same time, greater accuracy naturally means fewer rejects and less waste of raw material.

Whatever your particular component part design problem may be, we may be able to suggest and help you work out a practical and economical solution based on our more than 30 years' experience in forming metals. Send details of your problem to Commercial Shearing & Stamping Company, Department S-21, Youngstown, Ohio.

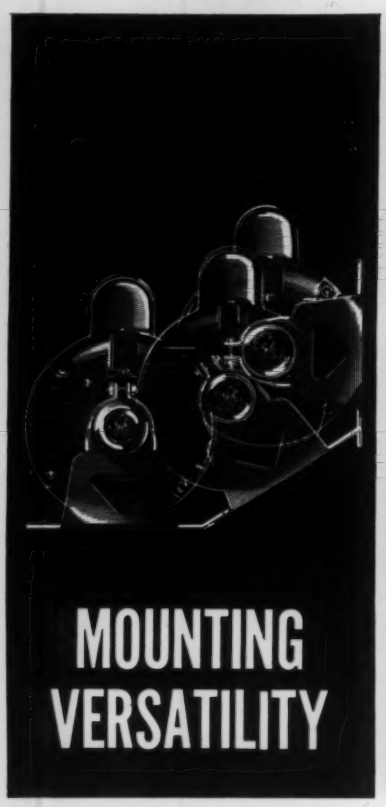
COMMERCIAL shearing & stamping

Circle 500 on Page 19



DESIGN ENGINEERS...

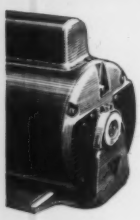
SIX WAYS

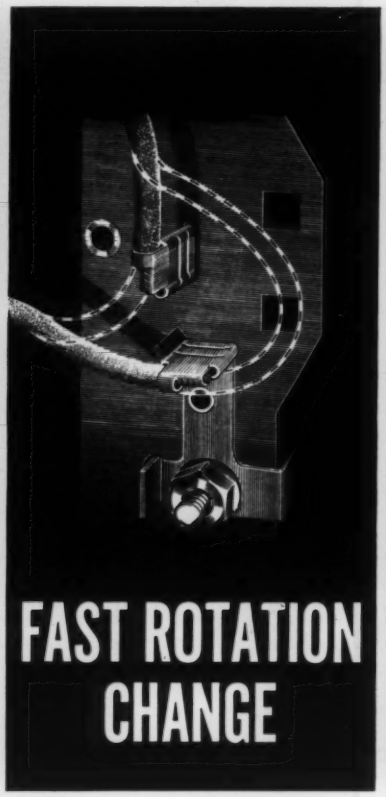


MOUNTING VERSATILITY

Cradle bases, both solid and resilient, allow rotation within base

You can rotate the Form G motor within the cradle base to take advantage of its drip-proof design, or you can position the motor with the capacitor at various angles for tight-squeeze applications. Or, you can remove the cradle base if you don't need it for your application. G-E Form G mounting versatility can mean greater design flexibility for you!

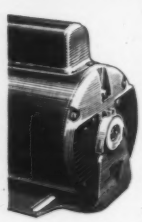




FAST ROTATION CHANGE

Now you can reverse Form G shaft rotation in less than 10 seconds

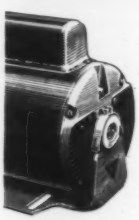
No need to specially order motors to meet your rotation requirements. G.E.'s Form G motor features a new wiring method that lets you change rotation in seconds. Quick connectors make the change fast and positive. Just interchange the two motor leads on the terminal board. That's all. Require fast, easy rotation change? The Form G is your motor!



EASY, DIRECT MOUNTING

Close end shield tolerances allow direct mounting without costly machining

General Electric standard Form G's can be mounted directly on your product without expensive machining or costly brackets. Close end shield tolerances, plus inherent shaft-to-end shield concentricity, lets you mount General Electric's Form G's with simple through bolts. This feature could be a real money saver for you. Why not investigate it today?

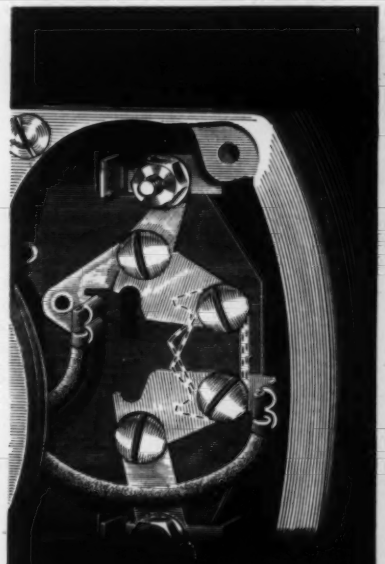


GENERAL ELECTRIC GENERAL ELECTRIC GENERAL ELECTRIC

JUST ASK YOUR GENERAL ELECTRIC SALES ENGINEER

Cut costs with General Electric Form G motors . . .

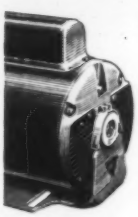
MORE VERSATILE



FAST VOLTAGE CHANGE

Unique sliding plates on terminal boards make voltage change simple

Reduce inventory, simplify ordering! You can change General Electric Form G motors from 115 v to 230 v operation (or vice versa) in 1/5th the time, without confusion and error. No special tools required! A screwdriver is all you need. Just loosen the four screws, pivot the plates to the new position and tighten the screws. That's all there is to it!



ALL-ANGLE OPERATION

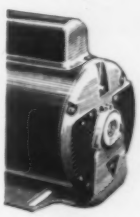
Special bearing and oil retention system permits mounting in any position

Mount it horizontally, vertically—even upside-down—the new Form G has the versatility to match the design and space requirements of your product. An advanced bearing and full oil retention system allows you to mount the Form G in *any* position and still be sure of getting faithful motor performance. In any position, Form G's do the job!

COMPLETE LINE

Full line of Form G's means the right motor for every application

There's a standard Form G motor to meet your exact product requirements. No need for costly specials. Over 850 basic models—and thousands of variations—are available on a mass-production basis. Let your General Electric Sales Engineer show you the all-around versatility of Form G motors and how they can provide important savings for you!



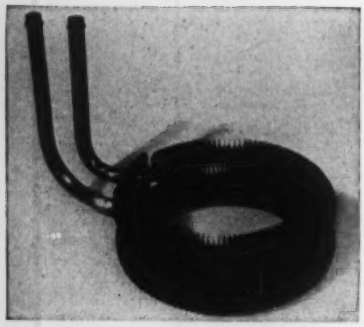
702-92

GENERAL ELECTRIC GENERAL ELECTRIC GENERAL ELECTRIC

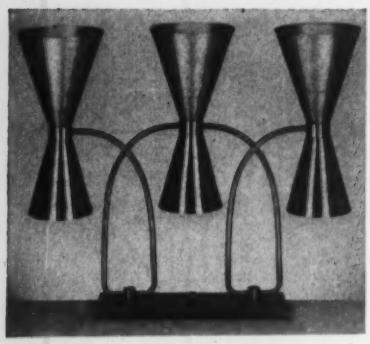
ABOUT THE NEW FORM G "EXTRA VALUE" FEATURES

BRIDGEPORT BRASS
COPPER ALLOY BULLETIN

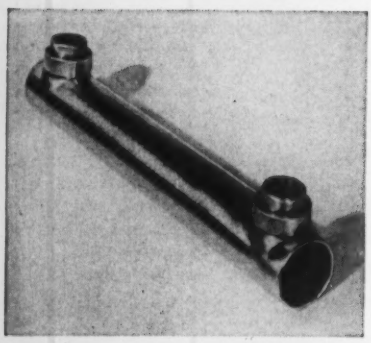
Reporting New Developments in Copper-Brass Alloys and Metalworking Methods



Conductivity and fast, low-cost fabrication are important qualities Bridgeport tube supplies for parts like this finned copper tube defroster coil.



High quality surface finish and easy workability are specified—and supplied by Bridgeport—in tube used in modern lamps like these.



Ease of fabrication, heat conductivity and corrosion resistance make copper tube the ideal choice for parts like this automatic transmission cooling unit.

WHY IT PAYS TO FABRICATE WITH BRIDGEPORT SEAMLESS TUBE

Bridgeport brass and copper seamless tube is an unusually versatile metal form which has a host of qualities, characteristics and uses few other metals can provide. Used in lamps, andirons, automotive parts, cooling units, furniture and other items, it fills a wide range of product and production requirements.

Why Seamless Tube?

Fabricators select Bridgeport Seamless Tube for many reasons. Its beauty and warmth lend much to the appeal of consumer products, for example. And its corrosion resistance and rustproofness make it desirable where other metals fail. Another important plus factor of seamless tube is its easy workability. Machining, bending, forming, cutting and cupping all are easier. Its wonderfully smooth surface finish simplifies polishing and plating. Close OD, ID and wall-thickness tolerances are maintained. This simplifies fabricating, keeps costs down and insures more uniform end products.

Economy...

In addition to the fabrication savings mentioned, additional economies are realized with Bridgeport Seamless Tube because it is produced in long lengths to insure uninterrupted production runs.

Characteristics...

Still another advantage is the wide range of characteristics available. You can specify combinations of mechanical, physical and fabrication properties as well as tempers to suit every need.

And Quality...

Made in one of the country's most modern tube mills, Bridgeport tubes are checked and inspected at every stage of manufacture to assure adherence to specifications. Bridgeport's other tests cover surface finish, interior strength, accuracy of gage and diameter, chemical analysis, strain, expansion and microstructure.

Find Out More

...about Bridgeport Seamless Tube in a wide range of brass or copper alloys for use in fabricating. Our Technical Service Men can help you solve application problems. Just call your nearest Bridgeport Sales Office, or, if you prefer, write direct to Bridgeport Brass Company, Bridgeport 2, Connecticut, Dept. 4301.

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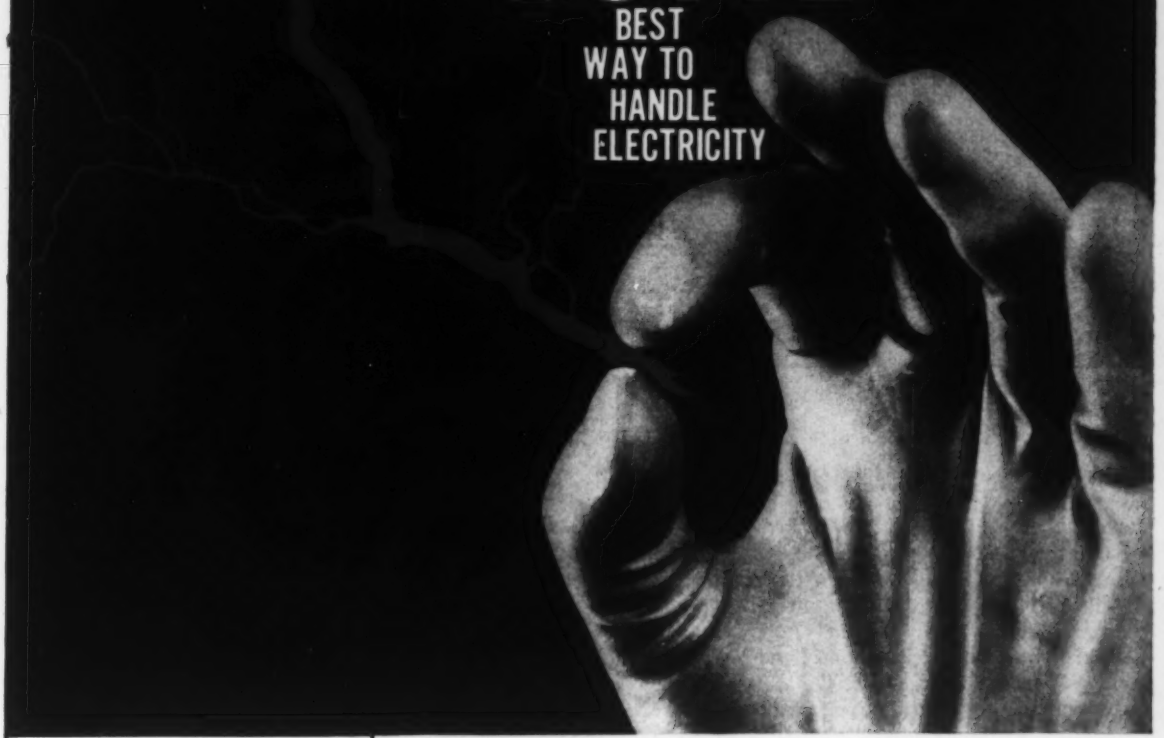
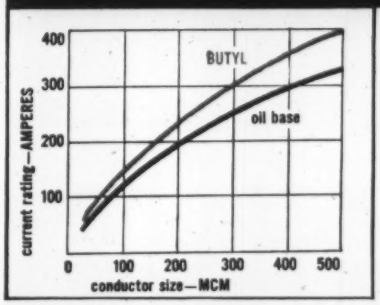
ENJAY BUTYL

BEST WAY TO HANDLE ELECTRICITY





Butyl's outstanding resistance to heat allows considerably higher currents for any given conductor size.

Of all vulcanizable rubbers, Enjay Butyl offers the best electrical and dielectric properties. Butyl is the ideal material for wire and power cable, transformers, tapes, busbars and other insulation applications.

Butyl *also* offers outstanding resistance to weathering and sunlight . . . chemicals . . . abrasion, tear and flexing . . . superior damping properties . . . unmatched impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

ENJAY® BUTYL

Pioneer in Petrochemicals

ENJAY

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

Circle 503 on Page 19

DYNAMIC DIFFERENCE

in hydraulic performance

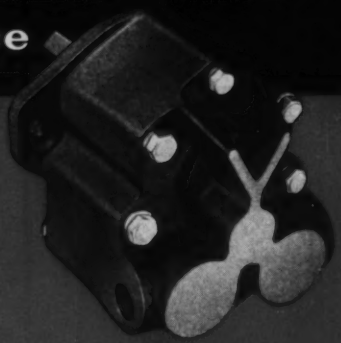
Webster

"HC" SERIES POSITIVE DISPLACEMENT GEAR-TYPE PUMP

Tough, tenacious . . . Terratrac! When this powerful diesel dozer flexes its hydraulic muscles, things *move!* Just a touch on the control lever triggers the action . . . a Webster "HC" pump follows up with a surge of oil power to handle big loads *fast.*

This is just one application of the big capacity "HC" series. There are many more. On all types of heavy industrial and road building equipment it powers demanding hydraulic jobs with speed, stamina and reserve.

And, there are additional reasons engineers specify the "HC" series . . . they're compact, adapt easily to the product and job, dependable. That's why when you figure on Webster, it adds up to *the dynamic difference that pays!*



"HC" SERIES POSITIVE DISPLACEMENT GEAR-TYPE PUMP

Shaft seal: lip type — Operating speeds: to 2400 rpm
Drive: direct, gear or belt — Porting: side (Std.) end (Opt.)
Capacity: 5 sizes, 5 - 17 gpm — Valve: optional; internal relief, adjustable 800 - 1500 psi
Pressure: to 1500 psi

BULLETIN HY1 gives complete engineering characteristics — performance and installation data.

Call the man from Webster

. . . he's one of a staff of engineers specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design.

photo . . . courtesy J. I. Case Company, Racine, Wis.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

our 50th year

Franklin adv. H-116

TAPER-LOCK STEEL CONVEYOR PULLEYS

Maximum strength with minimum weight...
Unmatched holding power on the shaft...
New mounting simplicity.

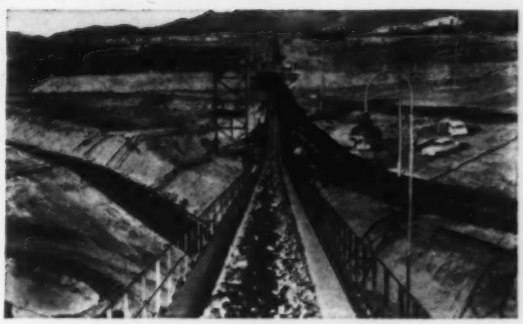
The rims, discs and hubs of these modern conveyor pulleys are *steel*—and they are fused together into jointless drum construction for (1) maximum strength with minimum weight, (2) exclusion of dirt, water, steam, (3) terrific shock resistance.

With the patented Dodge Back-up Bar, welds of full rim thickness are achieved—and the ultimate in strength is assured by submerged arc process welds.

Taper-Lock Steel Conveyor Pulleys *hold*. Taper-Lock provides the equivalent of a shrunk-on fit—there is no "walking" on the shaft. Mounting and demounting are simple. Pulley and bushings mount as a unit. Alignment is easy. And the tapered bushing is wedged into place merely by turning the mounting screws. It is "unlocked" by using the mounting screws as jack screws.

Available in diameters from 6 inches to 8 feet—all face widths. Standard or special rubber lagging available. Ask your local Dodge Distributor—or write us for bulletin.

DODGE MANUFACTURING CORPORATION, 3300 Union, Mishawaka, Ind.

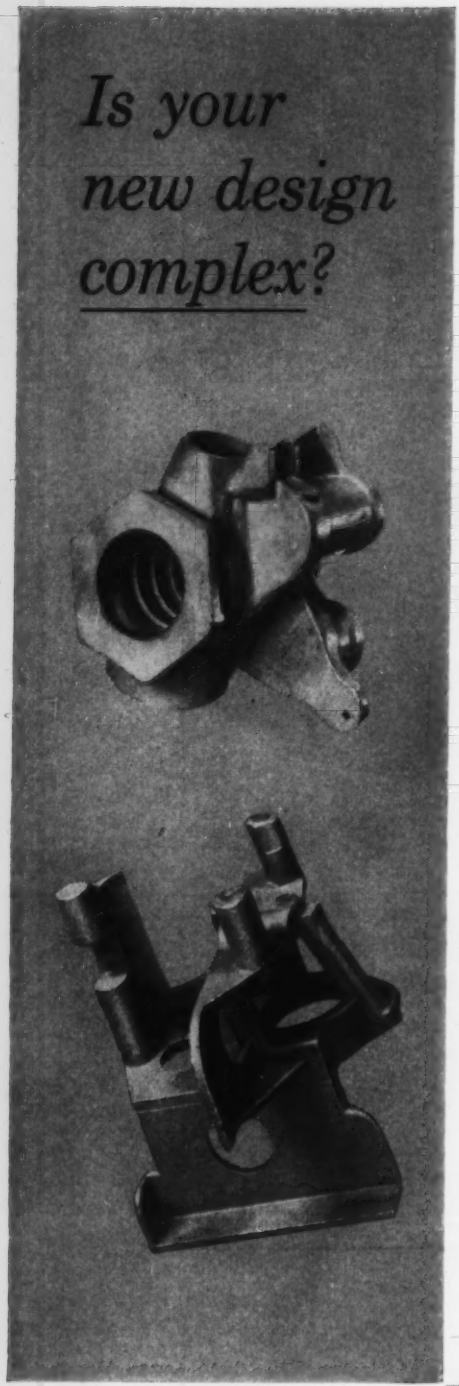


97 Taper-Lock Steel Conveyor Pulleys are used in this famous conveyor system engineered, manufactured and erected by Hewitt-Robins, Inc., at the Southern Pacific's causeway construction across the Great Salt Lake.

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

Is your new design complex?



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When you think you could cut production costs by making several parts as a single piece...

When function calls for a tricky shape but the intended service makes you specify, a hard, strong, tough-to-work alloy...

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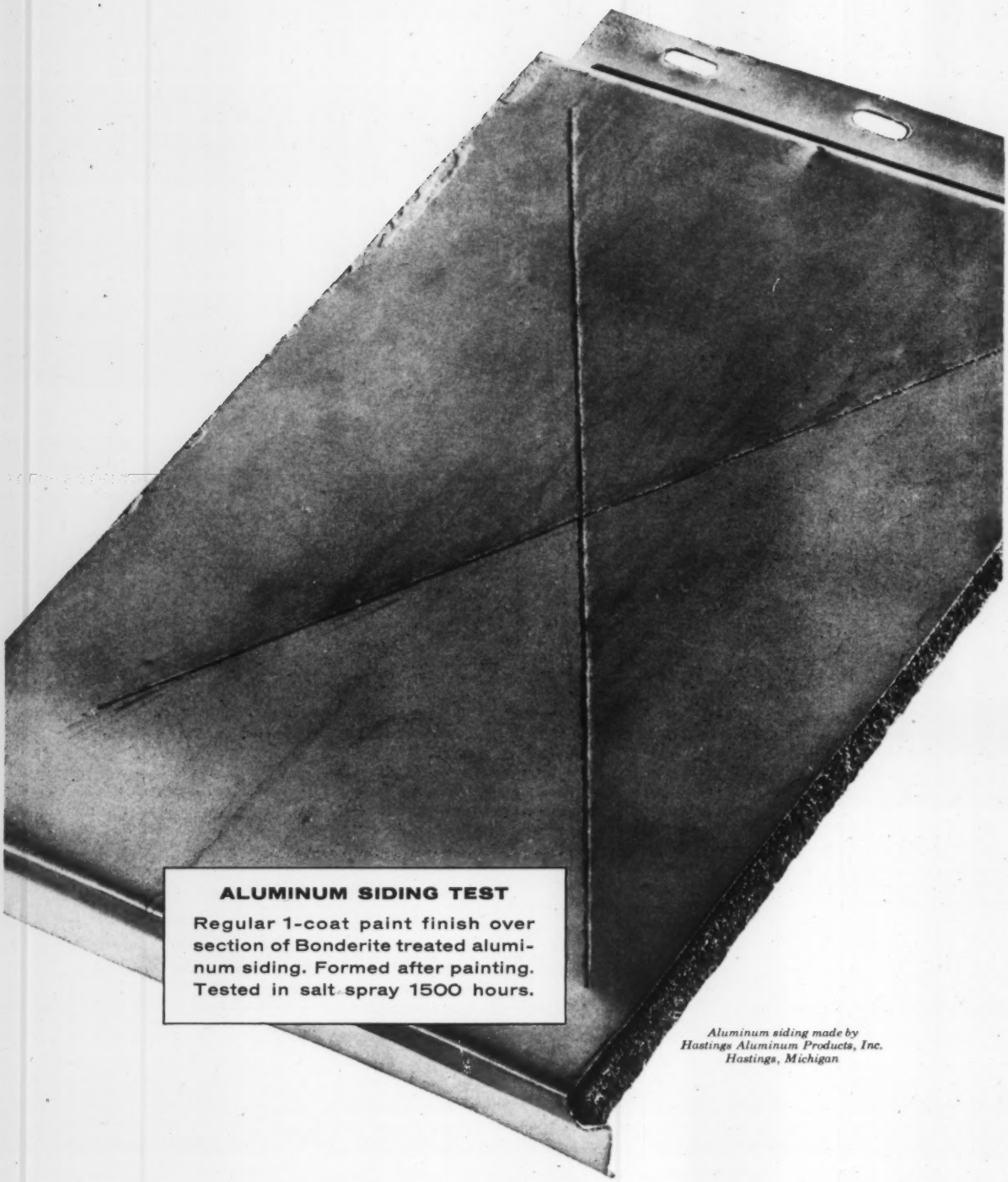
Circle 507 on Page 19

BONDERITE



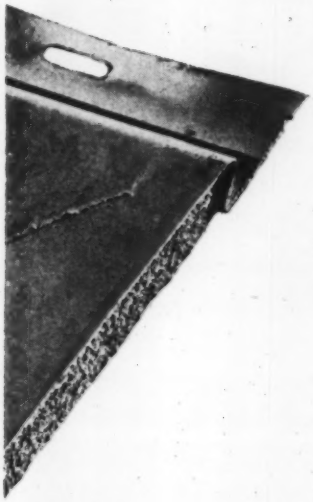
ALUMINUM SIDING TEST

Regular 1-coat paint finish over section of Bonderite treated aluminum siding. Formed after painting. Tested in salt spray 1500 hours.

Aluminum siding made by Hastings Aluminum Products, Inc. Hastings, Michigan

for ALUMINUM

Better paint adhesion...better corrosion control



In two hundred plants—many of them the leaders in their particular fields of aluminum fabrication—Bonderite for aluminum is being used today!

Bonderite makes it possible to take aluminum in the coil, run it through a continuous line in which the strip is cleaned, Bonderized, roll-coat painted, dried—and then recoiled.

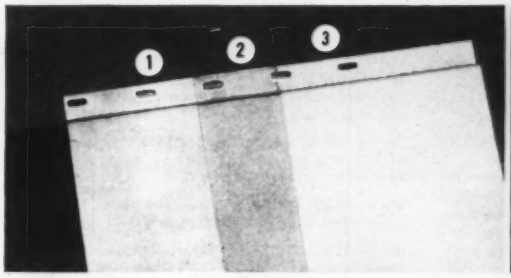
Because Bonderite gives paint such a secure foothold, it will stand severe forming operations (see photo below). With the Bonderite corrosion barrier at work, durability of the paint finish is almost indefinitely prolonged.

Bonderite meets and exceeds the requirements of Government Specification MIL-C-5541. Bare corrosion resistance is outstanding.

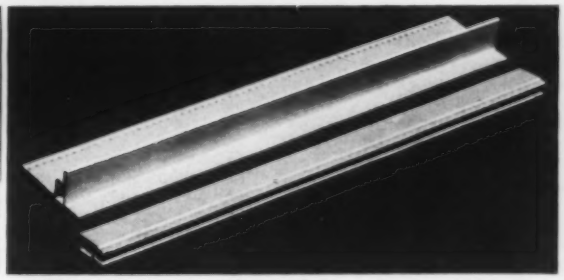
There's more than one type of Bonderite for aluminum. Besides the paint base, there's a Bonderite that creates a pleasant green coating, for use on architectural products. There's a Bonderite which protects without changing the characteristic color of the aluminum. Another Bonderite coats aluminum, steel and zinc—just the thing for mixed production.

There is a Bonderite, in fact, for every form of aluminum production, and for practically every alloy.

The big news in surface treatment for aluminum today is Bonderite! Let a Parker man tell you all about it!



Here's the 1-2-3 for durability of painted aluminum. Section of siding shows bare aluminum, (1); Bonderite treated, (2); and roll-coated paint, (3).



These aluminum window and screen frame sections were Bonderized and painted in the strip and formed after painting. There isn't a break in the finish anywhere!

Since 1914—leader in the field

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BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

*Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

Truarc Retaining Rings, the engineered fastening method for reducing material, machining and assembly costs

function		for axial assembly				for taking up end-play					
						axial assembly				radial assembly	
nomenclature		basic		inverted		bowed		beveled		prong-lock®	bowed e-ring
series no.		5000	5100	5008	5108	5001	5101	5002	5102	5139	5131
application		Internal for Housing Bores	External for Shafts	Internal for Housing Bores	External for Shafts	Internal for Housing Bores	External for Shafts	Internal for Housing Bores	External for Shafts	External for Shafts	External for Shafts
range	in.	.250-10.0	.125-10.0	.750-4.0	.500-4.0	.250-1.456	.188-1.438	1.0-10.0	1.0-10.0	.094-.438	.110-1.375
	mm.	6.4-253.8	3.2-253.8	19.0-101.5	12.7-101.5	6.4-37.0	4.8-36.5	25.4-253.8	25.4-253.8	2.4-11.1	2.8-35.0

function		for radial assembly				self-locking types					
nomenclature		crescent®	e-ring	reinforced e-ring	interlocking	circular self-locking			triangular self-locking	triangular nut	grip-ring
series no.		5103	5133	5144	5107	5005	5115	5105	5305	5300	5555
application		External for Shafts	External for Shafts	External for Shafts	External for Shafts	Internal for Housing Bores	External for Shafts	External for Shafts	External for Shafts	With Threaded Screw	External for Shafts
range	in.	.125-2.0	.040-1.375	.094-.438	.469-3.375	.312-2.0	.094-1.0	.094-1.0	.062-.437	•	.077-.755
	mm.	3.2-51.0	1.0-35.0	2.4-11.1	11.9-85.7	7.9-50.8	2.4-25.4	2.4-25.4	1.55-11.1	•	•

GENERAL DESIGN PRINCIPLE: Tapered construction permits rings to maintain constant circularity and groove pressure.

Series 5000 and 5100: Basic types for axial installation. Rings provide optimum groove strength.

Series 5008 and 5108: Best clearances. Accommodate parts having large corner radii or chamfers.

Series 5103: Best clearances. Secure against moderate impact, vibration.

Series 5133: Provides high coupling shoulders; accommodates wide groove tolerances. Easy servicing.

Series 5144: Reinforced E-ring. Five times more gripping strength, 50% higher RPM limits than standard E-rings.

Series 5107: High impact resistance; high coupling shoulders. Accommodates extremely high rotation and relative parts rotation.

Series 5001 and 5101: Resilient end-play take-up. Accommodate wide tolerances. Recommended for pre-loading bearings.

Series 5002 and 5102: Rigidly locked end-play take-up. Recommended for locking one race of parallel bearing assemblies.

Series 5139: Rigidly locked into position by protruding locking tabs. Provides high resilient end-play take-up with sliding tabs for uniform flexure. Cannot be forced from groove without destroying ring. Accommodates relative parts rotation. Equally effective with round, square, rectangular or hex shafts.

Series 5131: Provides high take-up. Recommended where clearances are a major problem.

Series 5005, 5115, 5105 and 5305: Prongs dig into shaft, locking rings against movement in one direction.

Series 5300: Spring tension locks parts assembled with threaded screws.

Series 5555: Self-locking against movement in either direction by spring tension. Since no groove is required, ring is adjustable to any position on shaft.

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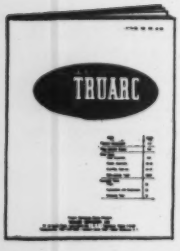

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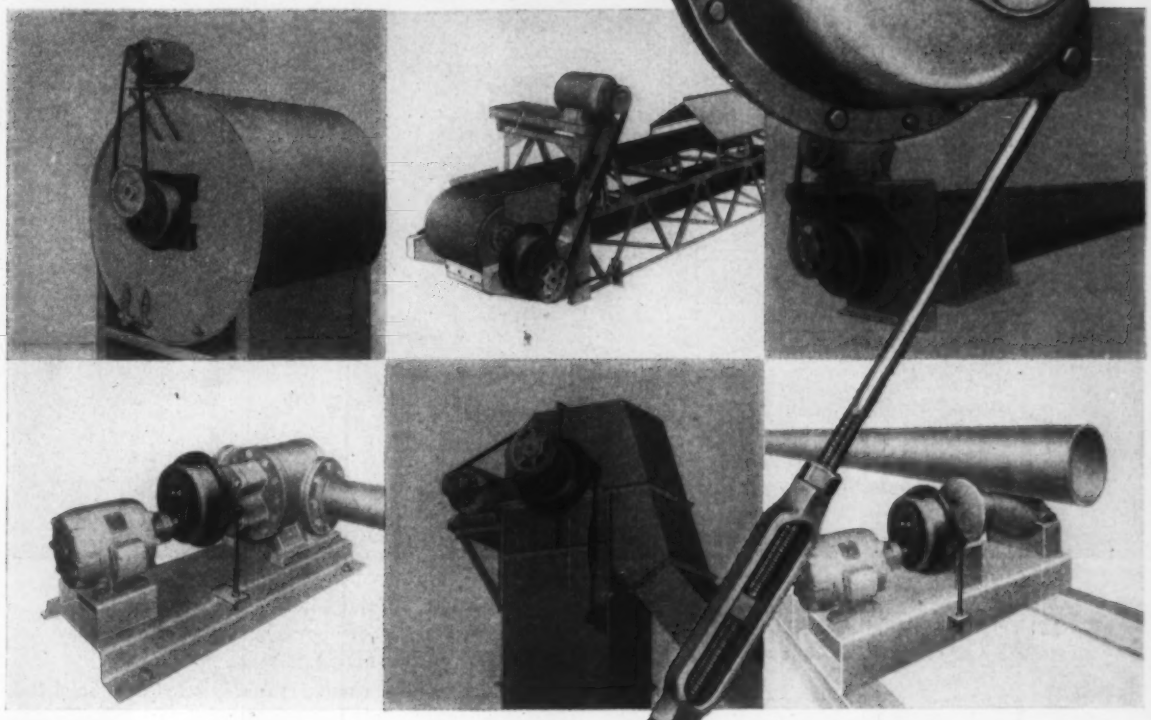
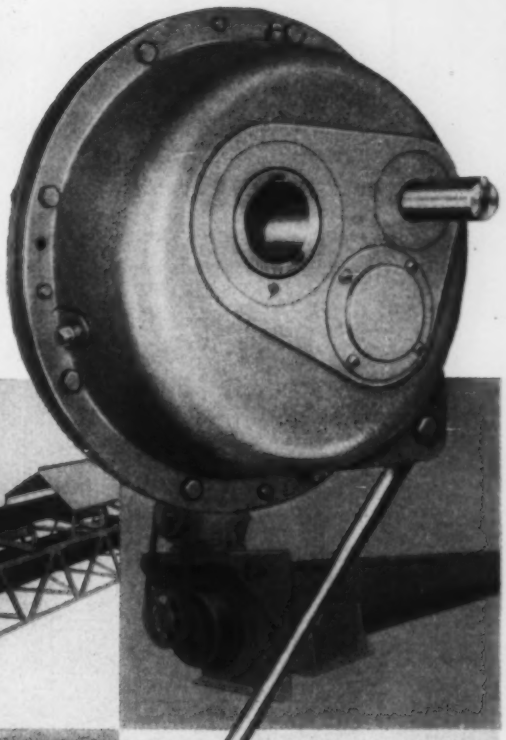
RETAINING RINGS

Waldes Kohinoor Inc., Long Island City 1, N. Y.

NEW! LINK-BELT shaft-mounted speed reducers





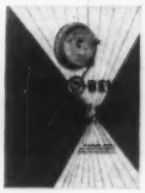
The ultimate in ease of purchasing, of mounting, of maintenance

No other shaft-mounted unit can equal the combination of convenience, dependability and precision provided by the new Link-Belt shaft-mounted speed reducer.

Installation is easy . . . requires no special tools. Motor and drive can be positioned to meet practically any space and application need. Tie-rod turnbuckle permits fast, sure belt tensioning . . . leakproof lubrication assures long-lasting service. In addition, Link-Belt simplifies purchasing and selection by offering pre-selected recommendations over a broad range of mechanical power transmission requirements . . . plus "off-the-shelf" availability.

For full facts on industry's newest shaft-mounted speed reducers, contact your nearest Link-Belt office or authorized stock-carrying distributor. Ask for Book 2618.

DESIGNED TO SIMPLIFY AND SATISFY THE MAJORITY OF SPEED REDUCTION JOBS, Link-Belt shaft-mounted speed reducers are made in single and double reductions up to 40 hp. Wherever they're used, they maintain lasting efficiency with such features as hardened precision gearing, live-action lubrication, long-life ball bearings and cast iron two-piece housing. Overload release device can be furnished as original equipment or applied in the field.



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14,947

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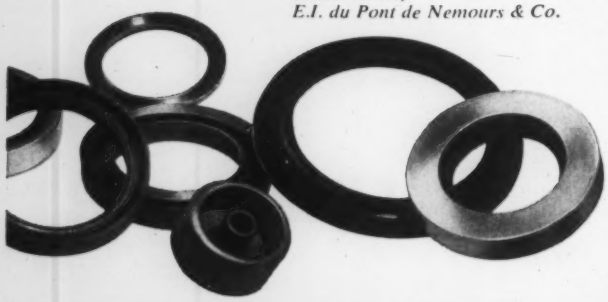

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P2

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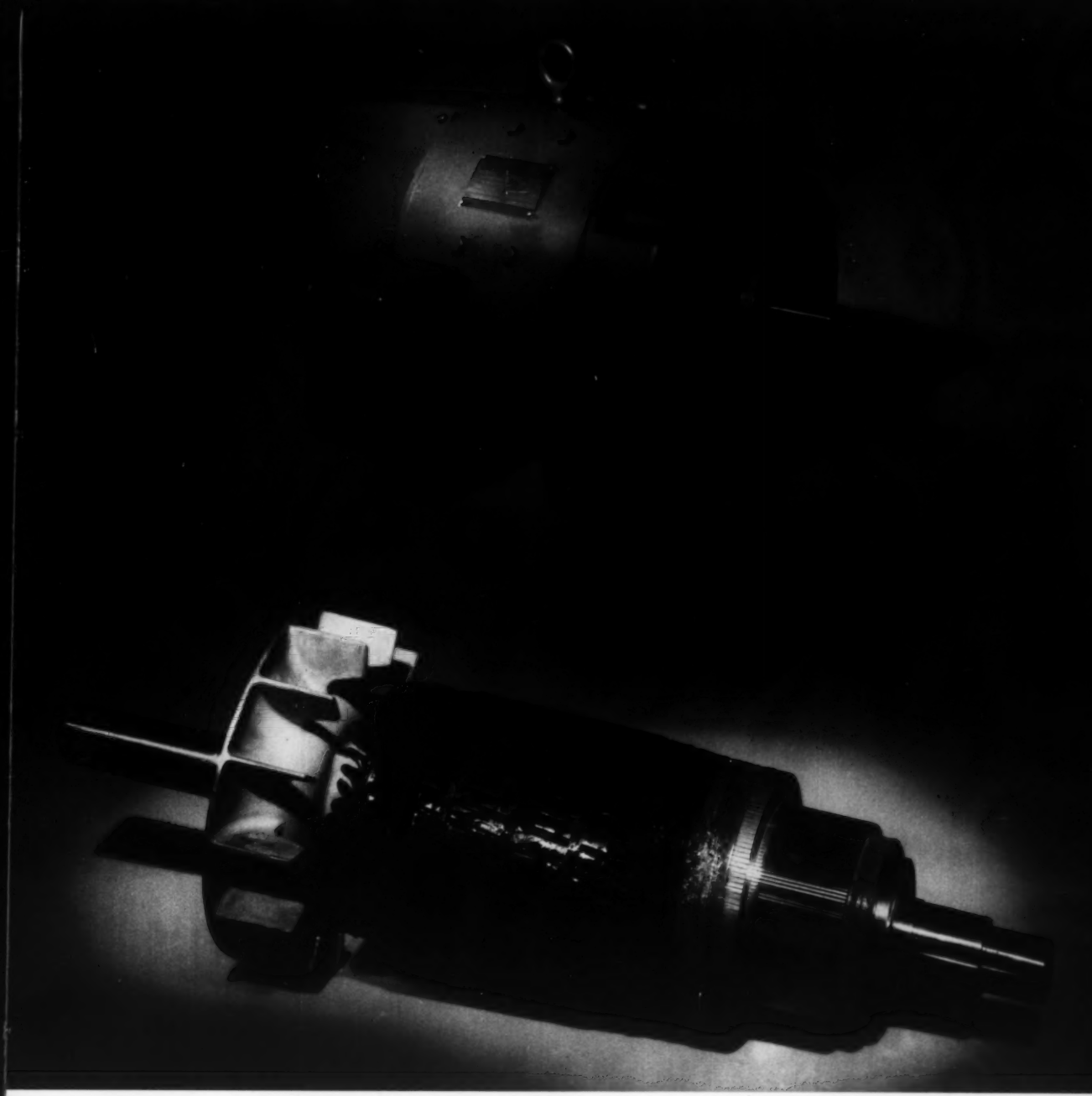
Circle 512 on Page 19→



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GENERAL ELECTRIC

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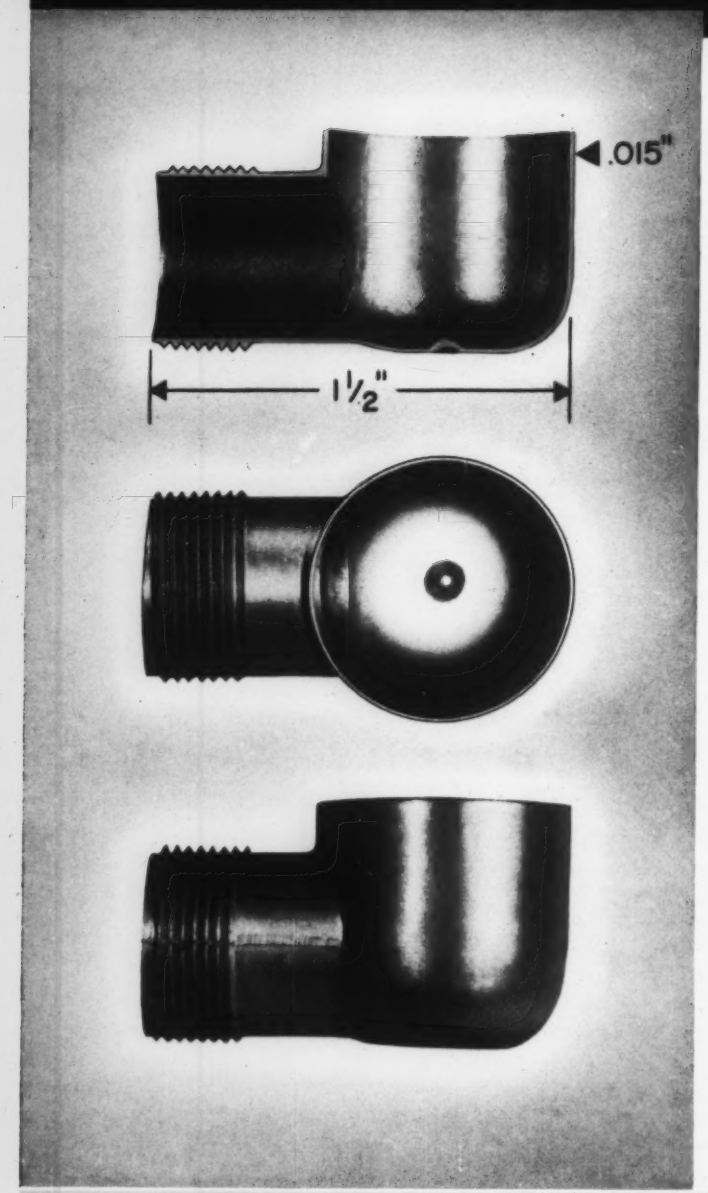

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Many zinc die castings are as thin as stampings, yet can be produced in shapes that cannot be duplicated as one-piece stampings.

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HORSE HEAD PRODUCTS®

Circle 513 on Page 19

MACHINE DESIGN

March 19, 1959

Unity—In Steel and Glass

PUBLIC recognition of engineering as a profession cannot be taken for granted. We do not deal directly with the general public, as most other professions do.

Now we are being offered a great opportunity to demonstrate whether our own declared dedication to our profession goes beyond mere lip service. The United Engineering Center, to be built close by the United Nations building, provides that opportunity.

As engineering society members well know, this $10 million symbol of engineering will serve the profession in many vital ways. It will house the great Engineering Societies Library, and will provide modern headquarters facilities for a score of engineering societies, including their publication offices. There will be conference and committee meeting rooms where, among other affairs, engineering standards and codes will be thrashed out. There will be display facilities for exhibiting to the general public the accomplishments and significance of engineering in the world of today.

Individual engineers are being asked to contribute $3 million toward this imaginative enterprise. Averaged among the members of the engineering societies involved, this amounts to about $20 per person, total, with pledge payments spread over three years if desired. Per year, that's equivalent to the price of one bottle of good Scotch —or three cartons of cigarettes— or one good ticket to a Broadway show.

Have engineers risen to the occasion? Here's the sad truth. While some have given generously—much more than the modest quota indicated—the majority seem to be sitting on their hands.

Industry and business — engineers' employers—are being asked to contribute $5 million, sixty-seven per cent more than the total of individual engineers. What will be their response when told that only a minority of engineers themselves have contributed at all?

Aren't we willing to dig down for a cause? Or is it simply that we haven't thought about it?

Colin Carmichael

EDITOR

To be patentable, an invention must be more than just an idea. It must work and it must be useful. Here are the yardsticks used by the courts in measuring

PATENT UTILITY

By **ALBERT WOODRUFF GRAY**
Forest Hills, N. Y.

THREE ingredients are essential for a valid patent: Invention, novelty, and utility. Like its predecessor, the present patent statute, which was adopted in 1952, provides, "Whoever invents or discovers any new and useful process, machine, manufacture or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor."[1]

In the shadowy realm between those inventions that are held by the courts to be useful and those that are cast out as useless and beyond the pale of patent law protection, the distinction is at times not too clear-cut.

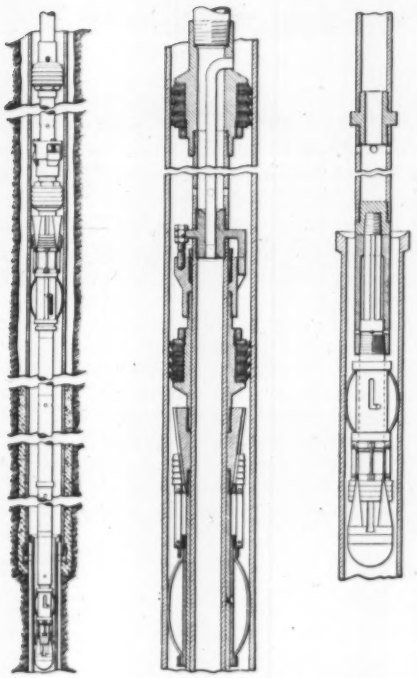
In their consideration of this necessary feature of utility, the courts face a twofold problem. Too rigid an insistance on this provision would rob inventors of protection under the patent statute and would destroy the incentive to progress, contrary to the purpose of the statute. On the other hand, disregard of this feature would take from common use, under the cloak of the patent monopoly, a host of items that are a part of everyday life.

A RECENT action before the United States Court of Appeals involved a patent of oil-well tools. Protest was made that the invention on which the patent had been granted failed to meet the provision of usefulness.

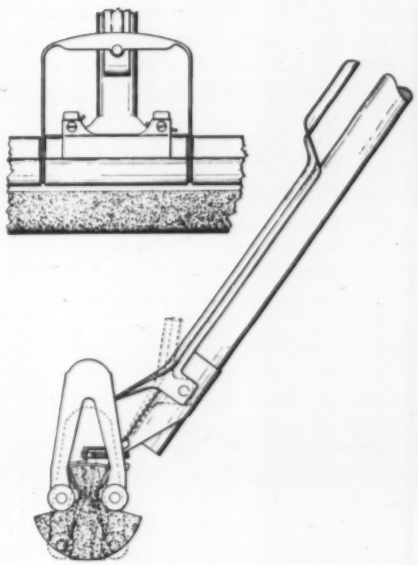
In this case, infringement was claimed of a "fishing tool," designed for removing objects that had stuck in oil wells. The device had been used once but unsuccessfully. When the tool had been pulled back to the surface the object sought to be rescued was found to have fallen into the shaft. In view of this fact, the trial court held the patent invalid for lacking the utility feature required by the statute.

Brought before the appellate court for review, that conclusion of the lower court was reversed. "The District Court's conclusion that the entire structure disclosed in that patent is useless appears to be

[1]References are tabulated at end of article.



Hydraulically operated "fishing tool" for removing objects stuck in oil wells. Patent on this device was granted in 1938. Later, in a court action for infringement of this patent, it was found that the device had been used once but unsuccessfully. Trial court declared the patent invalid for lack of utility. However, this decision was reversed by an appellate court on the basis that one unsuccessful experiment was not sufficient grounds for such a conclusion.



Patented sponge-rubber mop design on which an infringement suit was based. Defense contended that the invention lacked utility and was not patentable. At the time of the suit, over 2,000,000 mops had been sold during a low period in the national economy. In ruling the patent valid, the court held that the commercial success and widespread acceptance of the mop were, under the circumstances, sufficient proof of its utility and, to a certain extent, its novelty.

based merely on the one inconclusive experiment in which the tool was used but upon being pulled back to the surface, it was found that the 'fish' had escaped from the grapple. Since in any case no conclusion of general in-utility can follow from one unsuccessful experiment, we hold that the District Court went too far in invalidating the entire patent."[2]

SIMILAR, but more homely, were the circumstances involved in a suit against an Illinois manufacturer for the infringement of a patent of a sponge-rubber mop. Commenting on the defense of the infringer who contended that the device lacked utility and was therefore not a patentable invention, the United States District Court said,

"Upon determination of the validity of the patent, however, commercial success can serve as a corroborative aid. When this device was introduced the competitive item on the market was the conventional string or rag mop. The standard rag or string mop sold in 1935 at an average price of 49 cents; the patented construction sold at $2.95. Nevertheless this mop enjoyed widespread acceptance. More than 2,000,000 mops have been sold. In view of this large sale at a price much higher than the

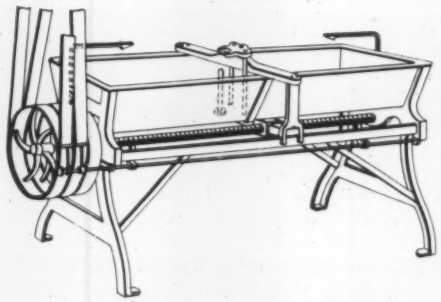
price of the standard rag mop during a period when this nation did not always enjoy financial prosperity, the court cannot agree with the contention that the acceptance of the patented structure is due solely to a successful advertising program."[3]

The statement relating to this mop was then supplemented by, "The wide acclaim with which it was received by housewives is proof of its utility and is at least some indication of its novelty."

BEFORE a federal court in Oregon many years ago, an action was brought by an inventor for an injunction against what was claimed to be an infringement of a patent for a candy-pulling machine. Defense to the action was that the invention lacked the feature of utility demanded by the statute.

In granting the injunction to the inventor, the court commented: "A device need not be perfect in order to escape the charge of inoperativeness. The test of operativeness is to ascertain whether the patented device does, even lamely and imperfectly, perform the acts claimed for it in the method described and perhaps for the reasons given."[4]

When the appeal from this decision came before the United States Supreme Court, it stated in affirmance of the conclusion of the lower court, "It is not necessary in order to sustain a generic patent, to show that the device is a commercial success. The machine patented may be imperfect in its operation but if it embodies the generic principle and works, that is, if it actually and mechanically performs, though only in a crude way, the important function by which it makes the substantial change claimed for it in the art, it is enough."[5]



Candy-pulling machine patented in 1906. Inventor of this machine brought suit for an injunction against what was claimed to be an infringement of his patent. Defense to this action was that the machine had never operated properly and, thus, was lacking the feature of utility required by the patent statute. The trial court, however, granted the injunction in a decision which was later affirmed by the United States Supreme Court. "The machine patented may be imperfect in its operation but if it embodies the generic principle and works, that is if it actually and mechanically performs, though only in a crude way, the important function by which it makes the substantial change claimed for it in the art, it is enough."

IN this decision, reference was made to another action brought by a linotype manufacturer for the infringement of the Mergenthaler patents. Here, also, the defense had been interposed that the patents failed to describe or claim an operative machine because the machines were incapable of making lines of the same length, and that the machine which produced the "linotype" was valueless because it did not produce an absolutely perfect "linotype."

Answer of the district court to this objection was, in part: "Such a proposition, if sustained, would condemn to obscurity some of the greatest works of human genius. A great poem may be marred because the meter halts at times, but it is a great poem still. Even the masterpiece of Rubens was improved by the touch of his pupil Van Dyck.

"It is true that the first specimens produced by the Mergenthaler machine are wanting in 'perfect justification.' They do show, however, that a great advance had been made in the art of printing even though the words were not spaced apart so as to be mathematically uniform at the extreme ends.

"Concede that the machine when first produced, was not perfect. It would certainly be a novel doctrine to deny to the inventor the fruits of a broad invention because the machine which first embodied it was rudimentary in character and failed to do as good work as improved machines made subsequently.

"None of the great inventions could survive such a test. Ten years after the invention of Howe, the machine first made by him would hardly have satisfied the least exacting sewing woman. The Dodds and Stephenson locomotive would, only a short time after its construction, have been discarded as behind the age, even by the savages of Tasmania. The telephone of Bell is not the perfected telephone of commerce, the Morse telegraph is looked upon today as an interesting antique. And yet it would be an unheard of proposition to withhold from these illustrious men the credit they deserve because their machines were crude at first and were improved afterwards."[6]

ONE of the earliest reported decisions involving this feature of the patent law established an interpretation that has been consistently followed

by the courts for approximately a century and a half. For the infringement of a patent for the manufacture of boots and shoes, suit had been brought in the federal court in Massachusetts. The defense maintained not only that the patent was not new but also that it was not useful.

"No person is entitled to a patent under the act of Congress," asserted the court, "unless he has invented some new and useful art, machine, manufacture or composition of matter, not known or used before. By useful invention in the statute, is meant such a one as may be applied to some beneficial use in society, in contradistinction to an invention which is injurious to the morals or the good order of society.

"It is not necessary to establish that the invention is of such general utility as to supersede all other inventions now in practice to accomplish the same purpose. It is sufficient that it has no noxious or mischievous tendency, that it may be applied to practical uses and that so far as it is applied, it is salutary.

"If its practical utility be very limited, it will follow that it will be of little or no profit to the inventor and if it be trifling it will sink into utter neglect. The law, however, does not look to the degree of utility, it simply requires that it shall be capable of use and that the use is such as sound morals and policy do not discountenance or prohibit."[7]

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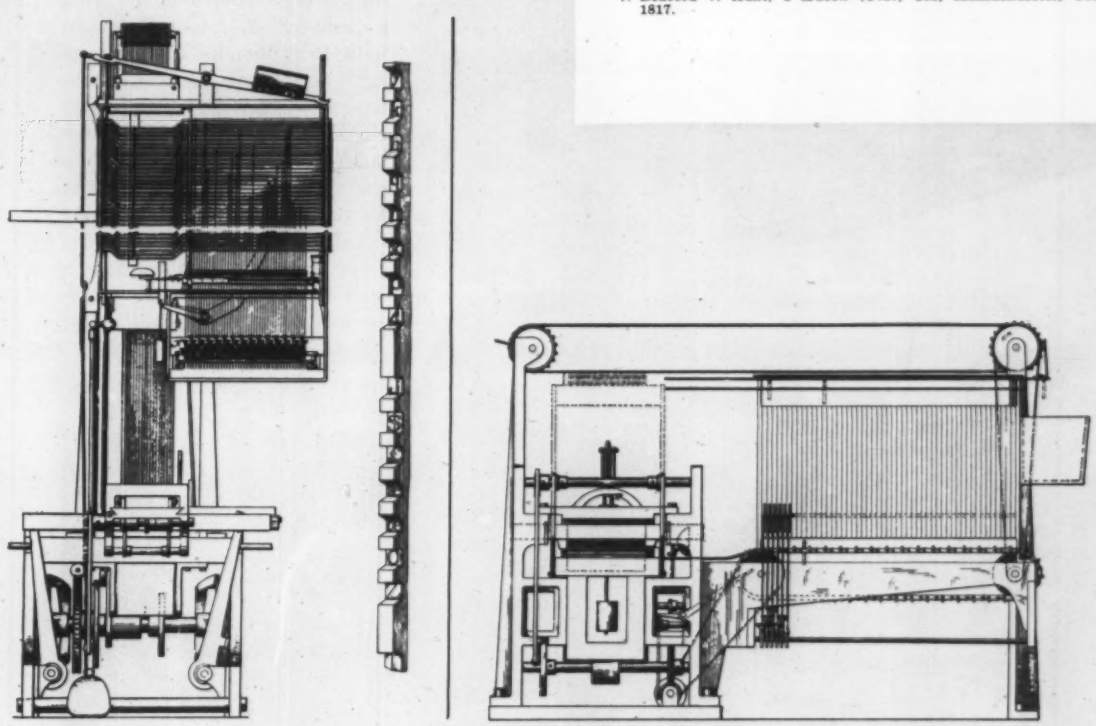
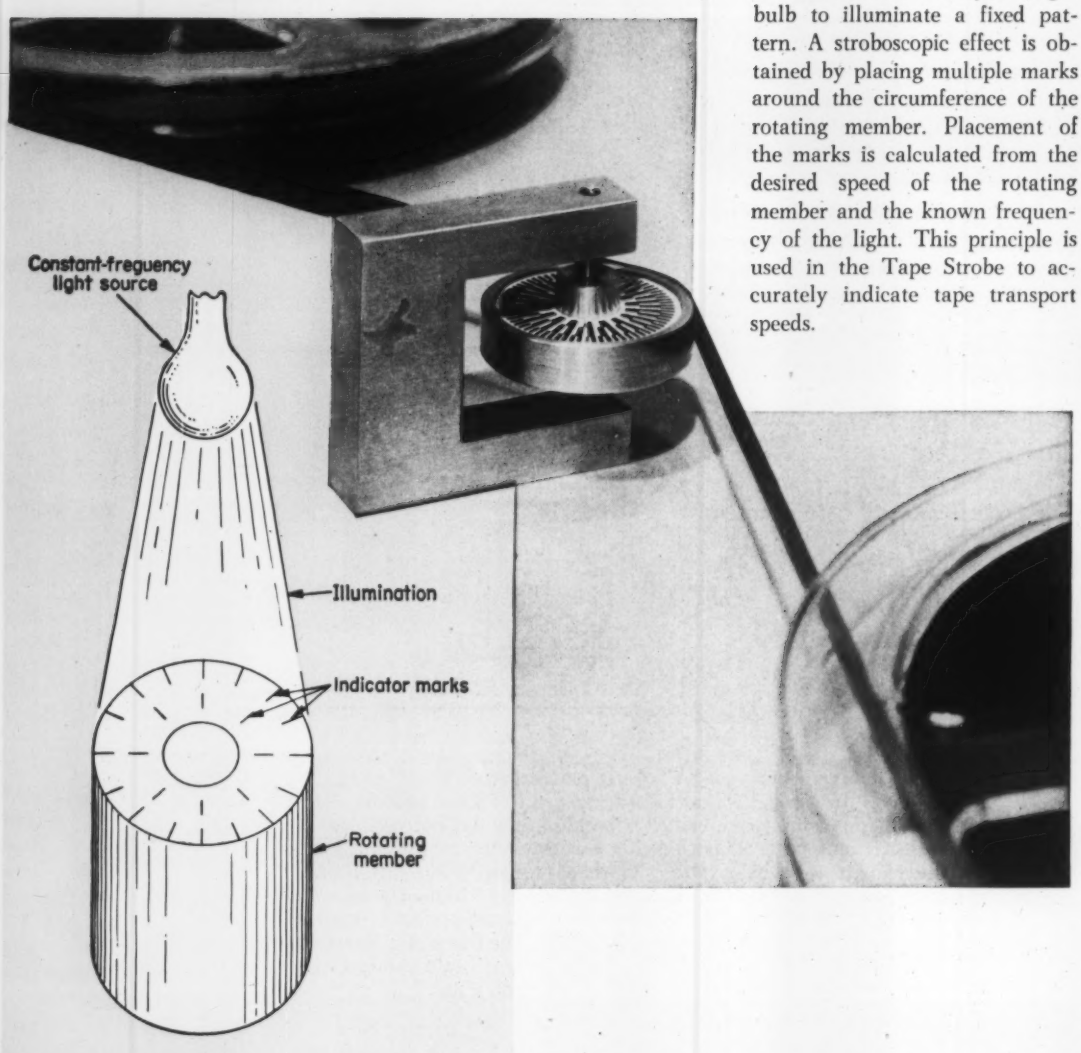
1. 35 *U.S.C.A.*, Sec. 101.
2. Hunt Tool Co. v. Lawrence, 242 *Fed.* 2d 347, Texas, March 15, 1957, reversing 142 *F.S.* 329.
3. Artmoore Co. v. Dayless Mfg. Co., 109 *F.S.* 181, Illinois, November 6, 1953, affirmed 208 *Fed.* 2d 1.
4. Hildreth v. Mastoras, 253 *Fed.* 69, Oregon, July 29, 1918.
5. Hildreth v. Mastoras, 257 *U.S.* 27, November 7, 1921.
6. Mergenthaler Linotype Co. v. Press Pub. Co., 57 *Fed.* 502, New York, July 21, 1893.
7. Bedford v. Hunt, 1 *Mason* (*U.S.*) 302, Massachusetts, October, 1817.

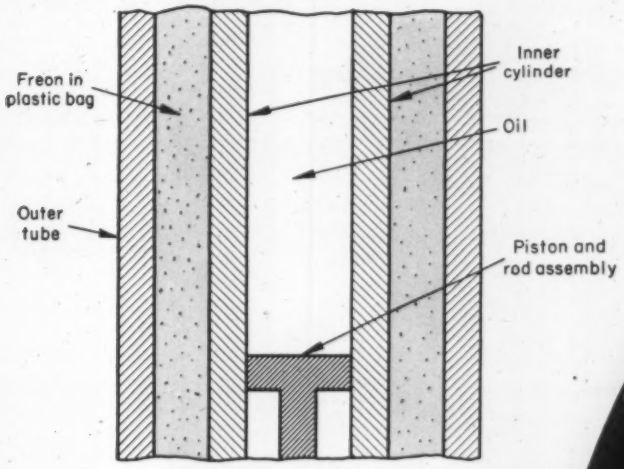


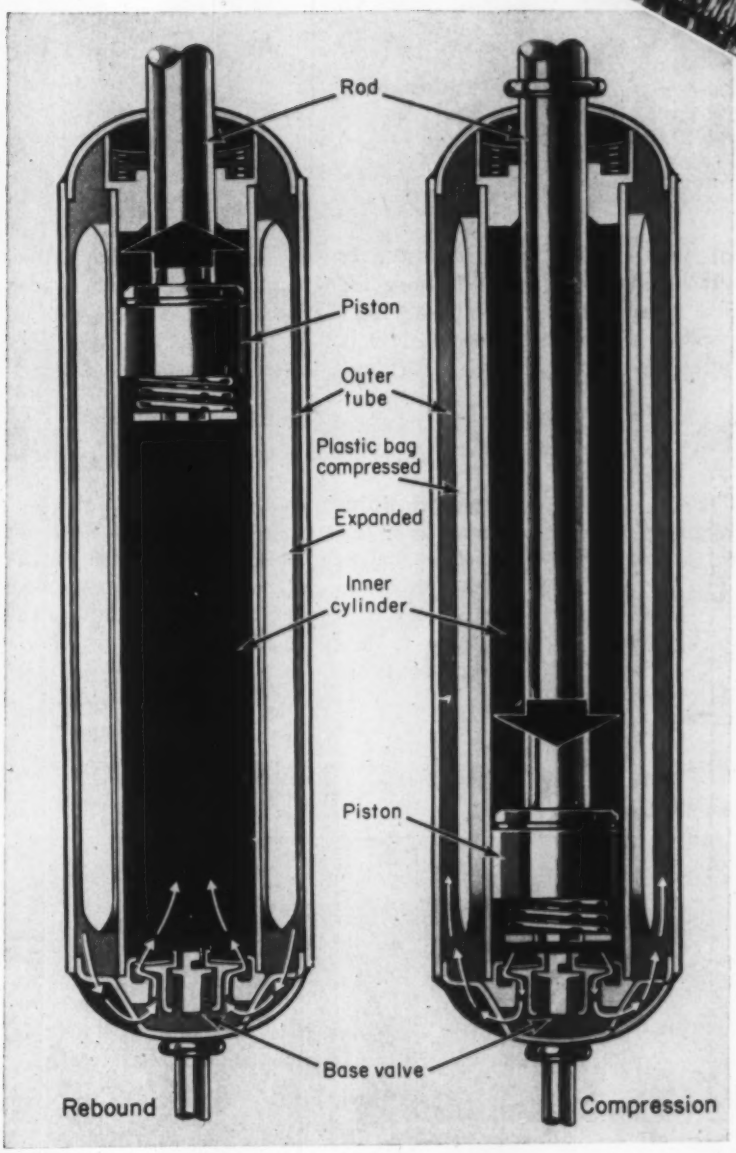
Early linotype machines on which patents were issued to O. Mergenthaler in 1885. In a court action for infringement of these patents, defense claimed that the machines were valueless because they did not produce an absolutely perfect "linotype." This objection was overruled by the courts, however, and the patents were held valid. "Such a proposition, if sustained, would condemn to obscurity some of the greatest works of human genius. . . . Concede that the machine when first produced, was not perfect. It would certainly be a novel doctrine to deny to the inventor the fruits of a broad invention because the machine which first embodied it was rudimentary in character . . . None of the great inventions could survive such a test."

scanning the field for *ideas*

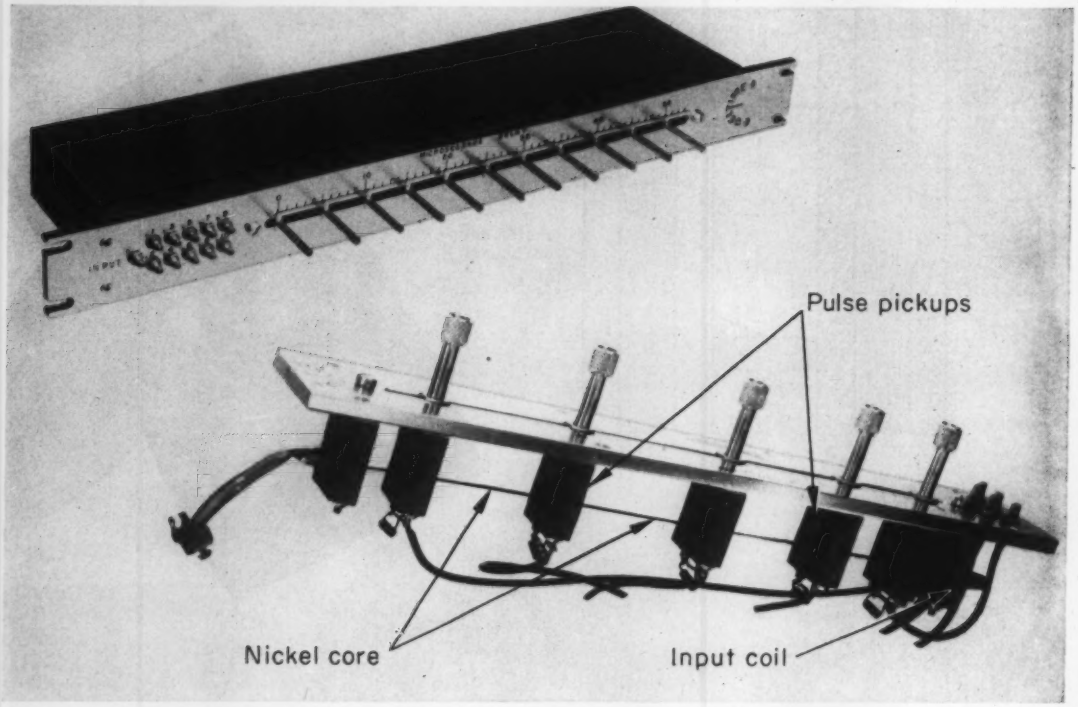
Speed indications of rotating parts are obtained by using a conventional 60-cycle light bulb to illuminate a fixed pattern. A stroboscopic effect is obtained by placing multiple marks around the circumference of the rotating member. Placement of the marks is calculated from the desired speed of the rotating member and the known frequency of the light. This principle is used in the Tape Strobe to accurately indicate tape transport speeds.



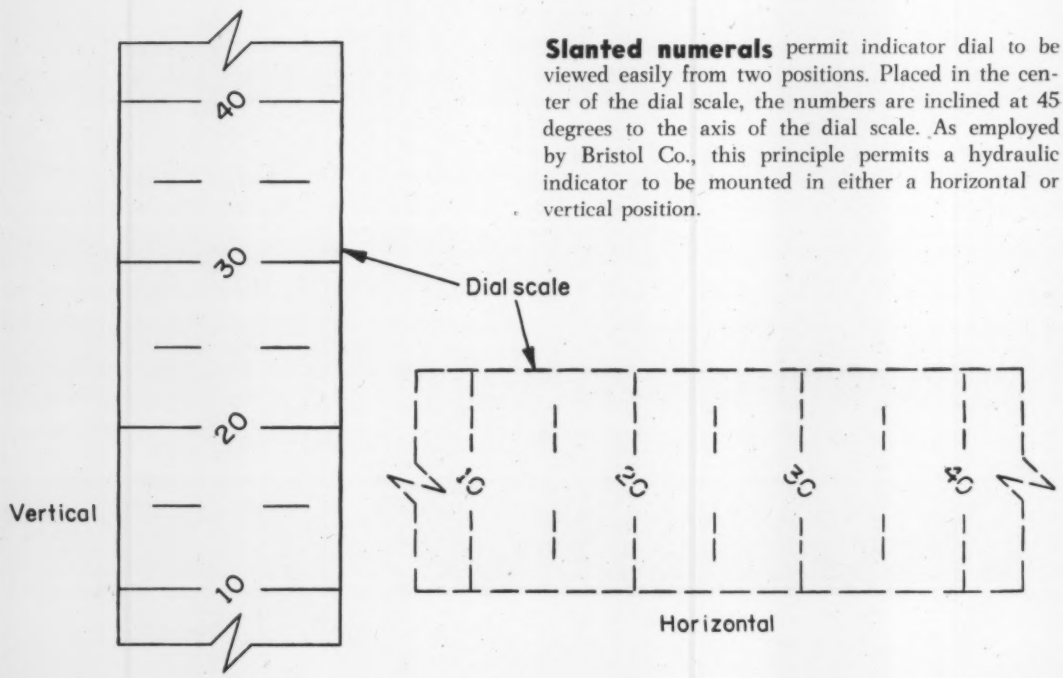




Bagged Freon eliminates aeration problems in gas-fluid snubber assemblies to maintain uniform density of the working fluid. In 1959 Cadillac shock absorbers, a plastic bag of Freon 12 replaces air conventionally used in the outside tube. As the piston and piston rod in the inner cylinder move through the oil, oil is forced into the outer tube and compresses the plastic bag. As the piston is withdrawn, the oil leaves the outer tube, the bag expands to fill the cavity.



Electronic "traffic" control shunts impulses through a nickel detour to slow down speed of signal transmission. The impulse is fed into a coil wrapped around a nickel core. Because of the magnetostrictive properties of the nickel, the electrical impulse is converted into a shock wave which travels along the core at the speed of sound. Different times can be obtained by picking up the pulse at various points along the core. This principle is used in Deltime's adjustable delay.



Slanted numerals permit indicator dial to be viewed easily from two positions. Placed in the center of the dial scale, the numbers are inclined at 45 degrees to the axis of the dial scale. As employed by Bristol Co., this principle permits a hydraulic indicator to be mounted in either a horizontal or vertical position.

Design Guide

ANALOG COMPUTING MECHANISMS

Special-purpose mechanisms for:

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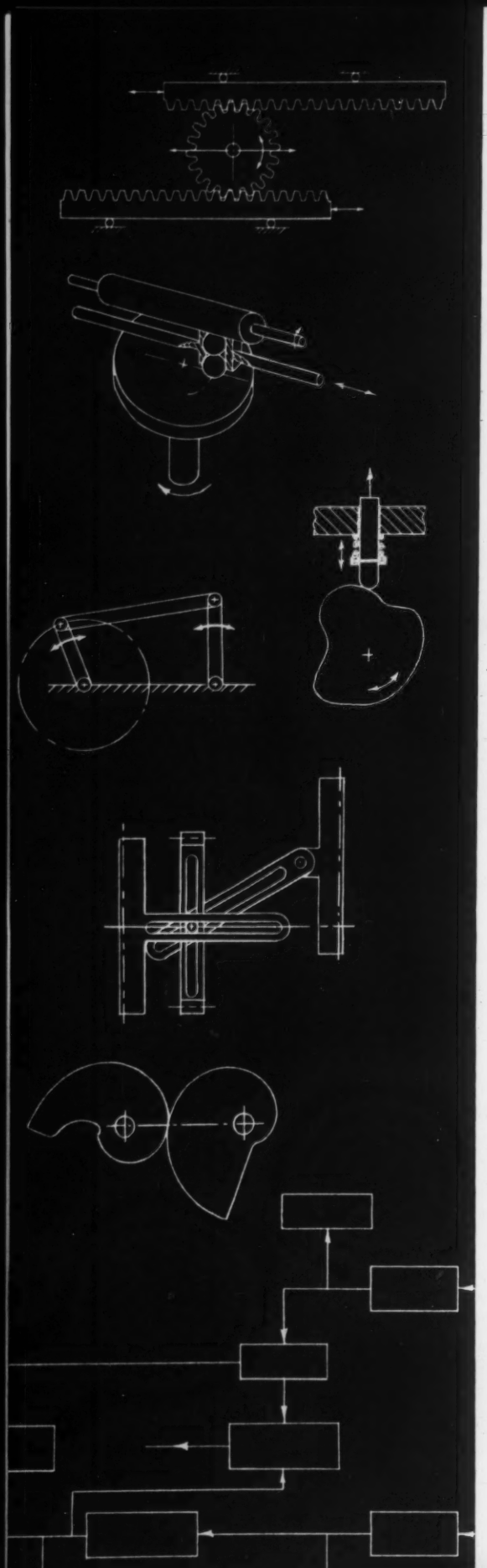
By GEORGE W. MICHALEC
Section Head
General Precision Laboratory Inc
Pleasantville, N. Y.



Survey and Evaluation:

Analog

MECHANICAL computation is the forte of mechanisms surveyed and evaluated in this article. They can add, multiply, integrate, find trigonometric functions, and handle almost any kind of functions or data in calculations.

Besides just performing arithmetic, they can serve as the brains of all-mechanical controls or as helpers in electromechanical control systems.

Such computing mechanisms contain the same kinds of elements that are common in other mechanisms or machines. But there are differences. Strength, power loss, appearance, etc., are secondary. Primary requirements are dictated by the mathematical operation to be performed. Precision must generally be of the highest order.

Displacements—rotary or linear—are the language of an analog computing mechanism. Mathematical relations it obeys in transforming input to output are the same as those describing the problem to be solved, except for a scale factor.

In point of time, the first computers were entirely mechanical. Slide rules and planimeters are good examples. Later, all-mechanical assemblies were powered with electric motors, as in the modern desktop calculator. Addition of other electrical components, such as servomotors, synchros, and potentiometers, creates a class of electromechanical machines. Computing mechanisms covered here are useful in electromechanical computers as well as in all-mechanical ones.

On a scale of relative complexity, massive all-electrical-electronic computers are the extreme opposite of all-mechanical types. A feature of the electronic types is high versatility which enables general-purpose use. The absence of versatility limits all-mechanical types to special-purpose applications. Despite this observation, electronic machines are not likely to displace mechanical types. In controls for automated processes and in applications which require rugged construction and high reliability, mechanical computers will continue to offer advantages.

Computing Mechanisms

for performing mathematical operations in all-mechanical or electromechanical computers

Addition and Subtraction

Operations of addition and subtraction can be performed by a number of mechanisms, all named differentials. The several mechanical types are named for their principal functional members. These parts include gears, gears and racks, discs or balls on plane surfaces, and linkages. Gear types are particular variations of the general family of epicyclic gear trains. Mechanical types, in general, are distinguished from electromechanical units, such as the differential synchro.

Of all mechanical differentials, the gear type, Fig. 1, is the most widely used. The gear differential is an old device, but still important. It continues to be the best means for negative and positive addition in control and computing circuits. Certain electromechanical devices perform the same operations, but less accurately than all-mechanical types. Except for size, gear differentials in computers are the same as differentials in motor vehicles.

In operation, the gear differential receives inputs on two shafts and delivers the answer on a third shaft. It adds or subtracts any number of revolutions or fractions of a single revolution, and it does this continuously.

Note that the word "differential" is not mathematically descriptive, for these mechanisms do not perform mathematical differentiation.

Performance of the Differential

Operation of a differential can be understood by analyzing its fundamental motion. In Fig. 2, a cylinder is in contact with two surfaces or planes.

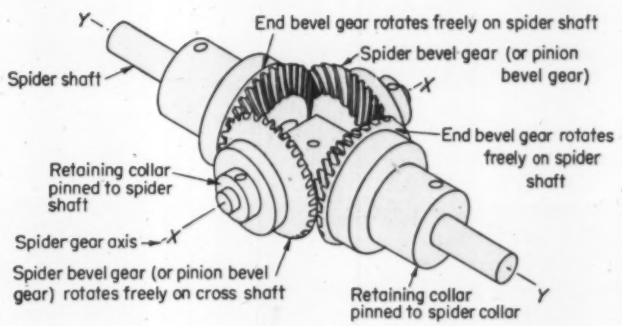

Y
End bevel gear rotates freely on spider shaft
Spider shaft
Spider bevel gear (or pinion bevel gear)
X
End bevel gear rotates freely on spider shaft
Retaining collar pinned to spider shaft
Spider gear axis
X
Spider bevel gear (or pinion bevel gear) rotates freely on cross shaft
Retaining collar pinned to spider collar
Y

Fig. 1—Elements of a bevel-gear differential

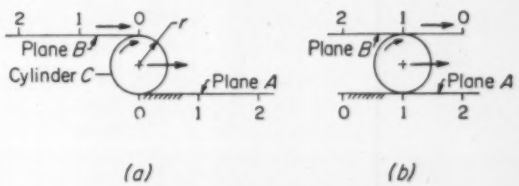


Fig. 2—Fundamental differential motion. View *a* shows initial positions. View *b* shows positions after cylinder has rolled a unit distance

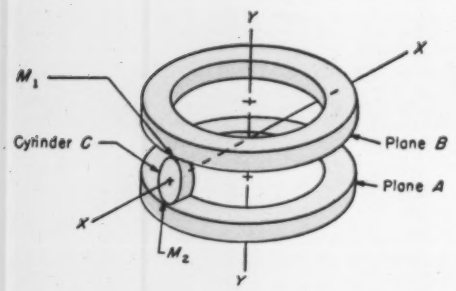


Fig. 3—Resolution of planes into rings, with cylinder *C* reduced to a disc rolling between them

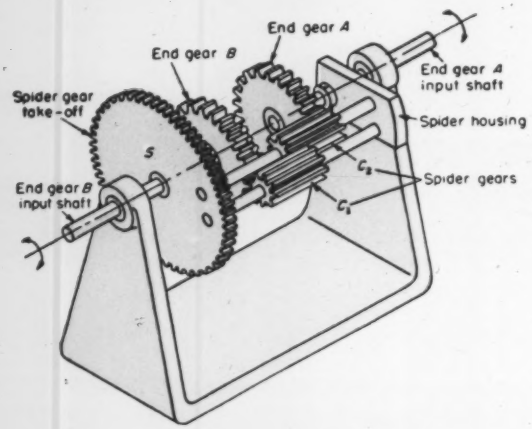


Fig. 4—Elements of a spur-gear differential

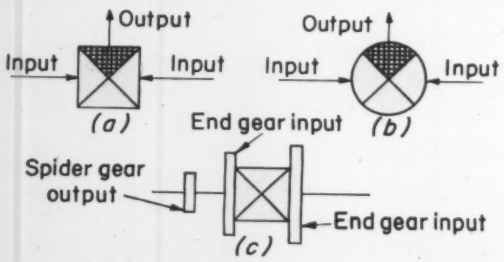


Fig. 5—Symbols for differentials: Square *a* and circle *b*, both with crosses, are used in schematics. Descriptive symbol *c* is used in gearing diagrams

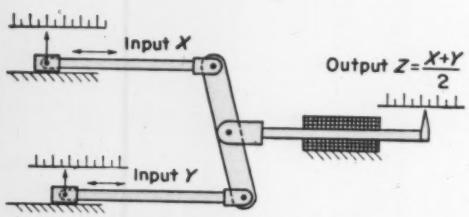


Fig. 6—Simple linkage differential

All three elements are free to have relative motion between one another as the cylinder rolls. In the transition of position from *a* to *b*, relative motion between the planes is twice that between the cylinder center and the planes, because the ratio of instantaneous radii of motion is 2:1. Position of the cylinder depends on the relative magnitudes and directions of the displacements of planes *A* and *B*.

If *A* and *B* are equally displaced but in opposite directions, the cylinder will be stationary. If they both move in the same direction with equal displacement, the cylinder will be moved in the same direction. Its total displacement will be the same as that of the two planes. When the planes are displaced in opposite directions, displacement of the cylinder will be a function of the algebraic difference of the displacements of the planes.

Note that the displacement of the cylinder is not equal to the full sum of the displacements of planes *A* and *B*, but one-half their vector sum. Diameter of the cylinder is not important even though its number of revolutions is inversely proportional to its diameter for given plane displacements.

Having a cylinder roll continuously between two planes is impractical because the planes must be infinitely long. This requirement is circumvented by twisting the planes into flat rings. The cylinder, reduced to a disc, rolls between them on a circular path, Fig. 3. To prevent friction-drive slippage, teeth can be imagined added to the planes and cylinder. The result is the positive-drive bevel-gear differential of Fig. 1. The equation of motion for the three elements is

$$N_C = \frac{N_A + N_B}{2}$$

where N_A and N_B = revolutions of end gears and N_C = revolutions of spider shaft.

The same equation applies to the spur-gear differential in Fig. 4. The internal gear ratio of 2:1 between the end gears and spider is a constant,

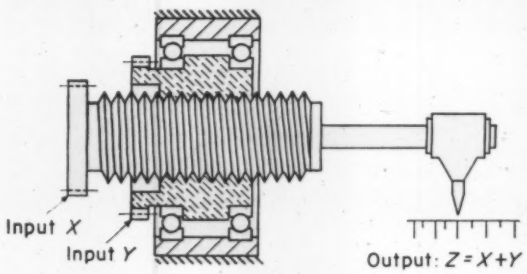


Fig. 7—Simple screw differential

which can be easily compensated for in applications.

Symbols commonly used for the differential in mechanical schematics are shown in Fig. 5. Note that there are two inputs and one output. The choice is open as to which leg is made the output.

Applications of the Differential

Mechanical differentials have so many applications that the details are beyond the scope of this article. However, three general uses deserve attention.

Changing Shaft Positions or Speeds: The most important use of differentials in computers and controls is to change positions or speeds of shafts. Specifically, differentials can be used to:

1. Add input data to a mechanism during continuous operation without disrupting internal action.
2. Zero phases of a mechanical device, thus avoiding either driving the entire mechanism or introducing slip clutches.
3. Change the phase relationship of shafts in either static or dynamic conditions.
4. Alter the relative speed of shafts.

Note that the word "differential" is not mathematically descriptive, for these mechanisms do not perform mathematical differentiation.

Measuring Torque: If the differential is applied as a fixed through gear train, reaction on the third leg is a measure of transmitted torque. From a calibrated restraint on the third leg, static and dynamic torques can be measured.

Braking or Clutching: The differential can be used as a safety locking brake or clutch. If one leg is braked to a predetermined load, the drive operates through the other leg until the transmitted torque exceeds the brake value. Then the drive is through the braked side of the differential and the unit acts as an overload safety clutch.

In still other applications, forking the drive into two branches, with only one in action at a time, may be desired. Placing brakes on the outputs and controlling them allow alternate operation of either leg without the need of a slip clutch in the system.

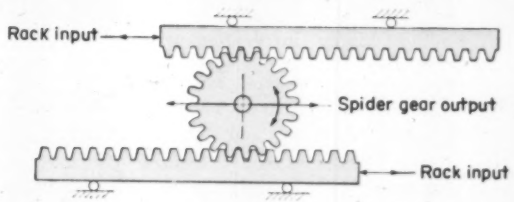


Fig. 8—Linear differential employing racks and a gear

Errors and Accuracies

Inherent in the gearing of differentials are two errors that at best can only be reduced to minimums. They are backlash and angular inaccuracy of transmission.

Backlash is the angular motion between the end gears when one of them and the spider shaft are held fixed. This measurement must be for a specified torque loading to be valid. The total lost motion is the accumulation of true gear backlash, bearing looseness, and strain in the system.

Inaccuracy of transmission is the nonlinear transmission of velocity ratio and results in position error. Essentially it is due to pitch circle runout and tooth-to-tooth errors.

The larger the gear elements, the better the chance of reducing angular errors. Unfortunately, the trend is toward smaller units, which places a greater burden on design and manufacture.

Currently, instrument gear differentials can be purchased as stock items having backlashes in the range of 5 to 10 minutes for loadings in the order of 2 to 6 oz-in., with working diameters of about one inch.

Other Mechanical Differentials

In addition to conventional gear differentials there are mechanical types which use only a few gears, or none at all. These are:

Linkage Differential: Linear motion of the linkage differential, Fig. 6, lends it particularly to linkage computers and other linear-motion devices.

Screw Differential: Particularly useful where inputs are rotary and output is to be linear, the screw differential, Fig. 7, is also effective where high forces are involved.

Racks and Gear Differential: Two linear inputs and a linear output are the special features of the rack and gear differential, Fig. 8.

Possibilities: Although the conventional bevel-gear or spur-gear differential has an internal gear ratio of 2:1 between the end gear and spider, other ratios can be obtained by special design. Generally their design requires end gears of unlike diameters, often best accomplished with an internal gear as one end gear. Analysis and design of such differentials are readily handled by considering the unit as an epicyclic gear train and applying fundamentals of such trains.

Integration and Differentiation

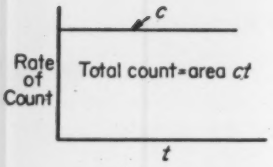


Fig. 9 — Constant-rate integration

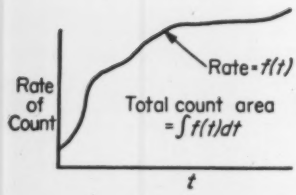


Fig. 10—Variable-rate integration

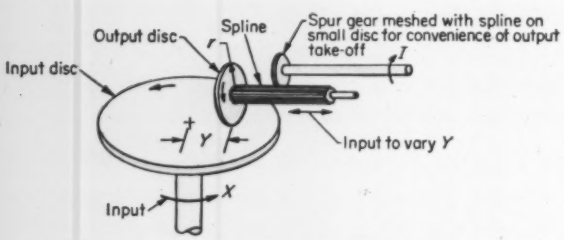


Fig. 11—Classical two-disc integrator

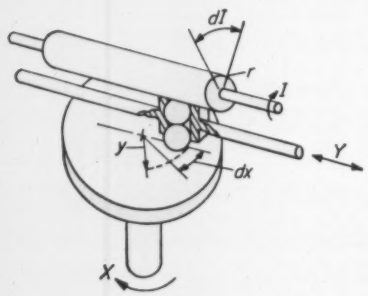


Fig. 12—Essentials of a ball-and-disc integrator

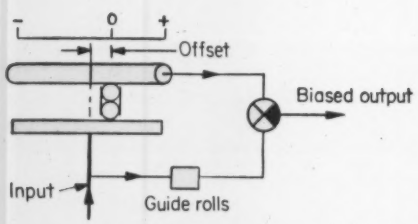


Fig. 13—Ball-and-disc integrator biased with a differential

Performance of integration is an important computer capability because the accumulation of a variable is often required. Integration for a fixed rate of change for the variable is readily accomplished by a counting device driven by a motor at a fixed speed, Fig. 9. The integration procedure is much more difficult when the parameter to be integrated is a varying function, Fig. 10 .

Design of analog integration devices can be illustrated by an example: Integrate the distance traveled by an automobile. A simple way is to have one of the wheels drive a counter which gives a measure of wheel rotation or distance traveled. The wheel rolling on the road surface does the integration.

If the integration is to be done remotely, an analogous system must be provided. It could be a continuously driven, smooth-surfaced disc to represent the roadway, and a smaller contacting disc to represent the auto wheel, Fig. 11. Distance of the small driven disc from the center of the large driving disc, y, could be varied to represent the speed of the auto. Thus, output rotation of the small disc would be distance traveled, and the two-disc device would be an analog integrator. This is the classical two-disc integrator for which I = rotation of the small output disc, r = radius of the small output disc, x = rotation of large input disc, and y = radial position of the small disc on the large disc.

From the geometry of the rotating system,

$$2\pi xy = 2\pi rI$$

$$I = \frac{1}{r}xy$$

Since x, y, and I can be functions of a variable, such as time,

$$dI = \frac{1}{r}y\,dx$$

This equation states that any small change in x produces a corresponding change in the output I, but y/r times as much. Integration of the equation yields

$$I = \frac{1}{r}\int y\,dx \qquad (1)$$

Value $1/r$ is known as the integrator constant, a significant term in system synthesis. Thus, I is an integral of a function with one independent variable. Note that the direction of the output is reversed and requires a sign change when the center of the disc is traversed (to negative y) by the output disc. This represents a real mathematical integral. With proper control of x and y, this simple speed changer can become an integrator of lengthy and

highly complex mathematical equations.

However, this unit is not a complete integrator in itself because it requires an accumulator, such as a counter, on its output. The rate of the small disc output is the derivative of the integral, or a velocity analog. In this example, it is the speed of the car.

Ball-and-Disc Integrator

The two-disc integrator has poor performance due to its low load characteristic. Output torque is proportional to the friction force between the two discs. Friction torque can be increased only by increasing the compressive load between them. Unfortunately, this would also increase the force necessary for sliding the small disc in order to vary the quantity y. Thus, the requirement for high torque output conflicts with the requirement of ease of shifting the take-off disc. Compromise results in low output torque which, in turn, necessitates a torque amplifier.

This limitation of the two-disc integrator is partly resolved by a ball-and-disc integrator. The output disc is replaced by two balls and a cylindrical roller. Thus, lower rolling-ball friction is substituted for high sliding-disc friction, Fig. 12. Use of much higher compressive forces results in significantly increased output torque.

Operating principle of the ball-and-disc integrator is identical to that of the two-disc integrator, and the same equations apply. Note that the integration constant, $1/r$, refers to the radius of the output roller. The ball radii are immaterial—they merely act as idlers.

Disc, balls, and roller are usually hardened steel alloys. This construction permits maximum compressive loads, and affords durability against wear and pitting. Carboloy discs are used in some of the most precise units. Size of the integrator is determined by the diameter of the disc. Thus, a two-inch disc is a "two-inch integrator." Sizes range from $1\frac{1}{2}$ to 5 in. Several manufacturers offer commercial stock units.

Typical accuracy of precision units is 0.5 per cent up to 1 oz-in. load for units having a disc in the order of $1\frac{1}{2}$ in. diameter.

The ball-and-disc integrator is a highly reliable unit. It can be designed for fairly rough service and for convenient incorporation into mechanical systems. It is relatively inexpensive.

The ball-and-disc integrator has two major faults: 1. Since it depends upon rolling friction, output torque is limited to several ounce-inches if high precision is desired. 2. In regular operation, the balls cause more slippage and wear at the center of the disc than elsewhere.

Wear at the center of the disc can be eliminated or reduced by several methods. Zero output can be biased to a radial value between the disc center and edge by displacing the ball carriage a slight amount from the center of the disc at the zero or null value of the ball carriage input. A differential and by-passed input can compensate for the offset, Fig. 13. Also, the balls can be induced to rotate with the disc at center position by means of controlled guide rolls, or the low friction of a ball-bearing sleeve.

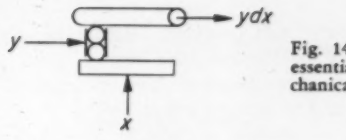


Fig. 14—Schematic essentials of a mechanical integrator

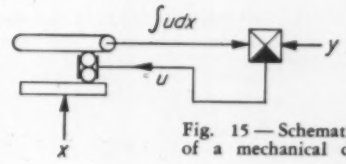


Fig. 15 — Schematic essentials of a mechanical differentiator

Integrator Applications

The ball-and-disc integrator can be used for three fundamental operations: Integration, differentiation, and speed changing. In integration, the integral can be a function of one variable input (disc speed fixed, ball-carriage position varied), or two variable inputs (both disc speed and ball-carriage position varied).

Mathematical Integration: For mathematical analysis, Equation 1 is written without the integrator constant, $1/r$. Hence,

$$I = \int y\,dx \qquad (2)$$

For this expression, Fig. 14 is the schematic representation. The ball carriage position (linear) is the function $y = f(x)$. Input to the disc is the quantity x, a circular measure of θ deg.

Since y must be linear in practice, rotary motion is converted to linear by a rack and gear, linkages, or the like. As the quantity x is varied, the disc input (x), and the ball carriage $y = f(x)$, are affected. The integral is the area under the curve. Adaptations of the integrator to varied conditions are shown in Computing with the Ball-and-Disc Integrator, pp. 164-165.

Differentiation: Mathematically, integration and differentiation are the reverse of each other. Therefore, one would expect that by reversing the integrator a differentiating mechanism would be obtained. However, to make the system feasible in a practical sense, a differential must be added. The result is a unit which theoretically does not give an exact mathematical solution, but, if applied properly, does give a usable answer. The schematic for this device is Fig. 15.

The integrator output is fed into a differential which has, as the other input, an angular value, y, which is a function of x. Output u of the differen-

tial positions the ball carriage. Positioning can be done by direct mechanical coupling, or, preferably, through power amplification. The differential inputs are arranged to be subtractive.

Suppose it is desired to obtain the derivative dy/dx of a known function $y = f(x)$. If the answer is assumed from the above schematic, the general integrator equation is

$$I = \int u\,dx$$

and the action at the mechanical differential is

$$y - \int u\,dx = \frac{u}{k}$$

where k is a fixed factor set to correct u in relation to the differential inputs. When this equation is differentiated with respect to x,

$$\frac{dy}{dx} = u + \frac{1}{k}\,\frac{du}{dx}$$

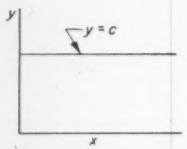
The assumed answer, u, is incorrect due to the second term, $(1/k)(du/dx)$. For the correct answer, this term must be zero, which can only be when $du/dx = 0$, that is, when the ball carriage is stationary. In practice, this does not occur because it would require infinite time. However, the error term can be minimized by setting k as large as possible without causing too high response of the ball-carriage motion.

Speed Changing: The standard ball-and-disc integrator can be a continuously variable speed changer. Precision construction enables adaptation to variable precision speed controls. However, in-

Computing with the

Output Proportional to Input

Let x be varied at a constant rate, such as a fixed speed input. Then x, the angle input to the disc, increases as a straight-line function. The carriage position is constant ($y = c$) and the plot is a straight line parallel to the x axis.

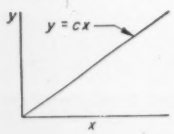


$$I = \int y\,dx = \int c\,dx = cx$$

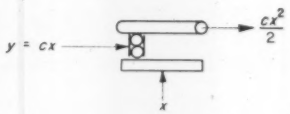
The area under the curve or integral, is the product xy or cx, since y is a constant. Constant c is the speed ratio of the integrator. For each ball-carriage position, there is a corresponding value of c.

Output Proportional to Input Squared

The integrator can be used to provide an output proportional to the input squared, if ball-carriage position y is varied linearly with x.



The integral or area under this curve is $cx^2/2$; hence, it is proportional to x^2. To produce this function, the integrator arrangement is

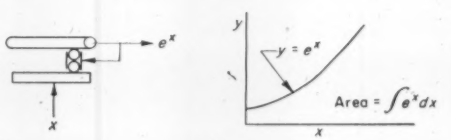


This arrangement is verified by substitution in the basic integrator equation.

$$I = \int y\,dx = \int cx\,dx = \frac{cx^2}{2}$$

Exponential Integral

Exponential output can be obtained by an integrator arranged for feed-back.



This arrangement is verified by assuming the answer and substituting in the basic equation,

$$I = \int y\,dx = \int e^x\,dx = e^x$$

Product of Two Variables

The product of two independent variables can be ob-

herent low torque capacity is a limiting factor.

Ball-and-disc units can be used as simple speed changers, Fig. 16. In this arrangement, the ball-carriage position determines speed ratio, which can be varied from infinite (at disc center) to a low which is the reciprocal of the integrator constant. Because of the wide range, this arrangement is not very precise, particularly for high values.

A more sophisticated arrangement resulting in precision speed control can be achieved with the arrangement in Fig. 17.

In this scheme, the speed control affects only a portion of the output speed, due to the by-pass and added differential. Precise control of a base speed can thereby be obtained over a limited range. By proper choice of gear ratio, the ball carriage can be limited to any desired portion of the disc.

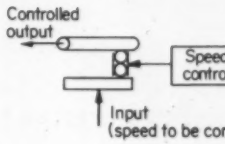


Fig. 16 — Ball-and-disc integrator arranged as a speed changer assembly

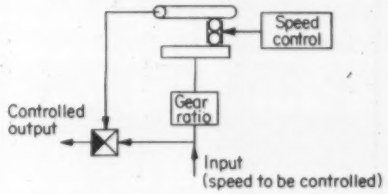
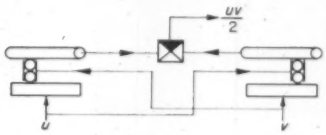


Fig. 17—Ball-and-disc integrator arranged as a precision speed control mechanism

Ball-and-Disc Integrator

tained by using two integrators and a differential.



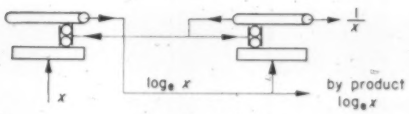
The arrangement is verified by substitution in the basic integration equation,

$$I = \int \frac{v\,du + u\,dv}{2} = \frac{uv}{2}$$

Note that the result illustrates the use of a mechanical differential.

Output Proportional to Reciprocal

Two integrators can be combined to yield a reciprocal output.



Again, proof is established by substitution of the assumed inputs and answers for y in the general equation. For the first integrator,

$$I = \int \frac{1}{x}\,dx = \log_e x$$

The output from the first integrator is the input to the second. Hence,

$$I = \int \frac{1}{x}\,d\log_e x$$

But,

$$\frac{d\log_e x}{dx} = \frac{1}{x}$$

Therefore,

$$\int \frac{1}{x}\,d\log_e x = \int \frac{1}{x^2}\,dx$$

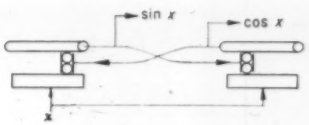
and the output of the second integrator is

$$I = \int \frac{1}{x^2}\,dx = \frac{1}{x}$$

A negative sign has no particular significance.

Sine and Cosine Functions

The trigonometric functions, sine and cosine, can be generated by means of two integrators.



The proofs are: For the output of the first integrator,

$$\int \cos x\,dx = \sin x$$

and for the output of the second integrator,

$$\int \sin x\,dx = -\cos x$$

Trigonometric Function Generators

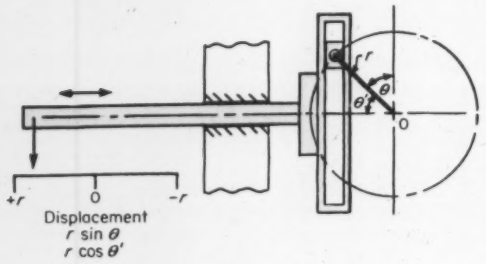


Fig. 18—Scotch yoke, a sine-cosine generator

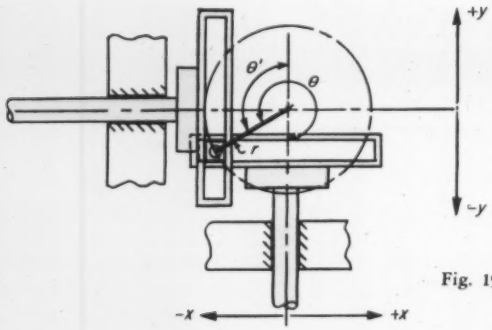


Fig. 19—Double Scotch yoke

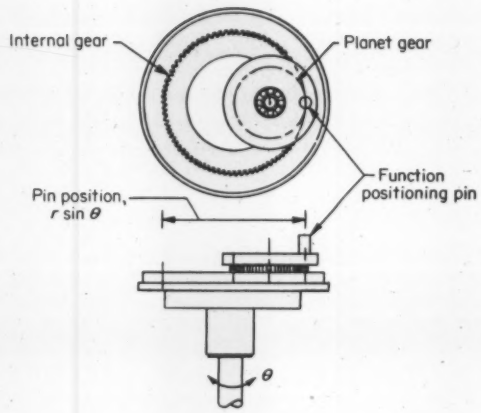


Fig. 20—Gear-type, sine-cosine generator

Trigonometric functions are generally obtained mechanically in two ways: 1. By mechanisms which reproduce the geometry of the function. 2. By cams and followers. This section pertains to the first group. Cam applications are covered later.

Sine-Cosine Mechanisms

Mechanisms which generate sine-cosine functions include the Scotch yoke, gears, eccentrics, and cranks.

Scotch Yoke: As shown in Fig. 18, the Scotch yoke consists of a rotating crank which is the input, and a driven sliding block in a slotted link, which is the output. This mechanism converts rotary motion of the crank into an exact sinusoidal linear output. With respect to complementary reference angles θ and θ', the Scotch yoke generates both the sine and cosine values simultaneously. To obtain both functions for the same angle, two Scotch yoke mechanisms are required. For compactness, they can have a common crank, Fig. 19. Such a combined unit can be used for directly resolving a vector quantity into components along rectilinear co-ordinates.

Gear Mechanism: A compact unit for obtaining exact sine and cosine displacements is illustrated in Fig. 20. This unit consists of a large internal gear and a meshing planet gear. The driving arm of the planet is the angular input. The two gears are proportional in size so that the planet pitch diameter is one-half that of the internal gear. A point on the pitch circle of the planet traces a hypocycloidal curve when the gears are rolled. However, because of the 2:1 ratio, this is a special hypocycloid, namely, a straight line. The point moves in a straight line with sinusoidal motion. The output pin in Fig. 20 is placed exactly over the pitch circle and, therefore, gives a sinusoidal output. The function can be either sine or cosine depending upon where the input is referenced.

A particular advantage of this design over the Scotch yoke is the absence of sliding parts. All motion is gear action and rotation of shafts in bearings, which results in a smoothly acting device with low friction. Standardized gear sine-cosine mechanisms are commercially available, specifically de-

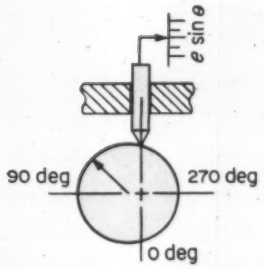


Fig. 21—Eccentric-cam, sine-cosine generator

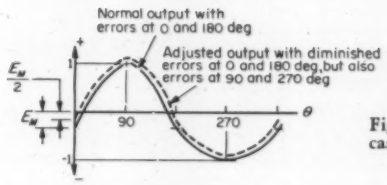


Fig. 22—Output error of eccentric-cam, sine-cosine generator

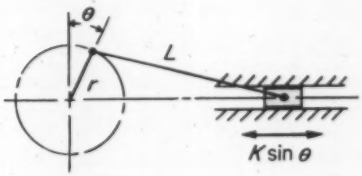


Fig. 23—Crank-and-slide, sine-cosine generator

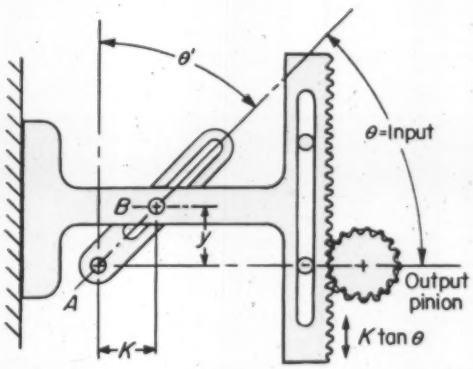


Fig. 24—Tangent generator

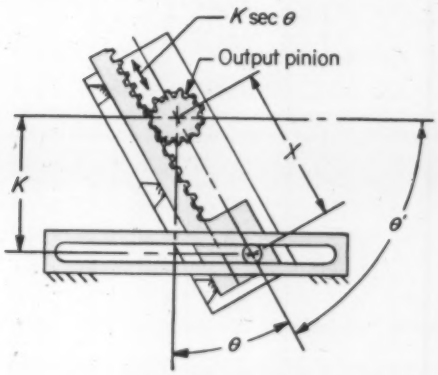


Fig. 25—Secant generator

signed to work with stock ball-and-disc integrators.

Eccentric Mechanism: An inexpensive means of obtaining sine and cosine motion is an eccentric driving a follower which is constrained to move in a straight line, Fig. 21. The driver is a simple circular cam mounted eccentrically. The output approximates a sinusoidal function. Fig. 22 is a plot of the output. The maximum error occurs at 0 deg and 180 deg and its value is

$$E_{max} = r - \sqrt{r^2 - e^2}$$

where r = radius of circular cam and e = eccentricity of mounting.

Obviously the error diminishes as r is made large and/or e smaller. Shifting the curve upward $E/2$ halves the maximum error, but now all cardinal points have some error.

Crank Mechanism: Another simple but approximate generator is the crank mechanism, Fig. 23. Its analysis parallels that of the eccentric, and a similar maximum error equation is

$$E_{max} = L - \sqrt{L^2 - r^2}$$

The error is split by shifting the curve $E/2$.

Tangent and Secant Mechanisms

A mechanism, Fig. 24, similar to the Scotch yoke generates the tangent function. However, in this device the pin is fixed in the output arm and the rotating arm is slotted.

From the geometry of Fig. 24,

$$y = k \tan \theta$$

Term y is the output position of the rack slide, or the take-off output position.

A limitation is high sliding friction which causes binding at θ values of 30 to 45 deg. This problem is related to the rapidly increasing value of the tangent which cannot be physically accommodated. This unit delivers the cotangent function at angle θ'.

The secant function is generated by a mechanism similar to the tangent generator, Fig. 25. From the geometry of the figure,

$$x = k \sec \theta$$

From observation, value x becomes infinite as

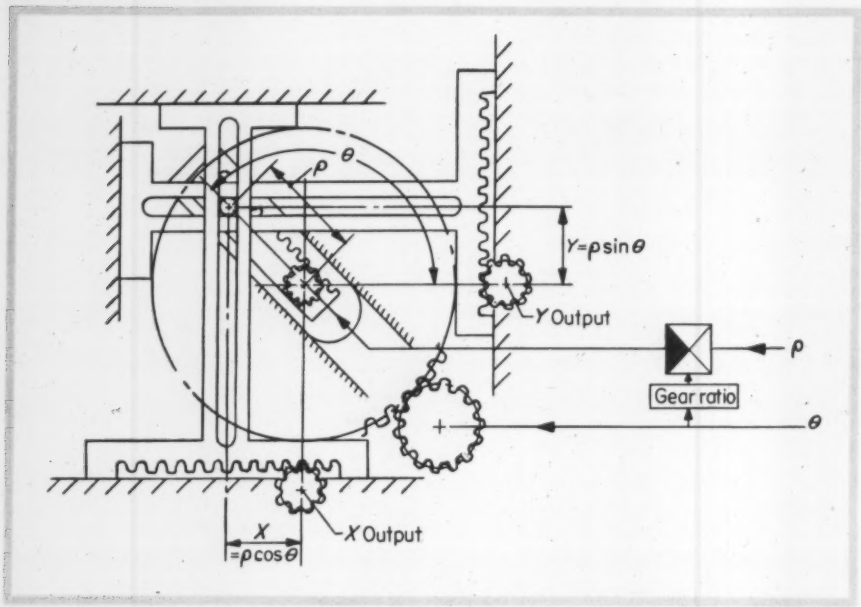


Fig. 26 — Essentials of a rack-type component solver

θ approaches zero—a physical impossibility. Practical considerations limit the value of θ to about 40 deg.

If the angle reference is shifted 90 deg so that θ' is the input angle, the unit delivers the cosecant function.

Component and Resultant Solvers

The component solver, or resolver, is another sine-cosine mechanism. It differs from the Scotch yoke and the gear-type sine-cosine mechanisms in that the radial arm, constant in these other devices, is a variable vector. It solves these functions:

$$x = \rho \cos \theta$$

$$y = \rho \sin \theta$$

where both ρ and θ are independent variables.

Rack-Type Component Solver: The rack-type component solver is shown in Fig. 26. It is similar to the double Scotch-yoke system, except for the provision for adjusting pin radius ρ by a rack and pinion.

If θ were the only input, the value of ρ would also change because of the rolling of the rack on the stationary ρ input pinion. To avoid this unwanted change in ρ, the angle θ input is fed to both the angle gear and the ρ pinion through a mechanical differential. Thus, rack and pinion motion are so compensated that variation in θ does not affect ρ. If pinion and rack are replaced with a traveling nut, screw, and bevel-gear input, the unit is called a screw-type component solver. A further variation is the cam type in Fig. 27. In this design, ρ input is set with a spiral cam.

Evaluation: Because mechanical component solvers contain many precision parts, their fabrication is expensive. Also, the many sliding parts incur high friction and, for high accuracy, their size must be large. In size or cost, these units do not compare favorably with electromechanical resolvers.

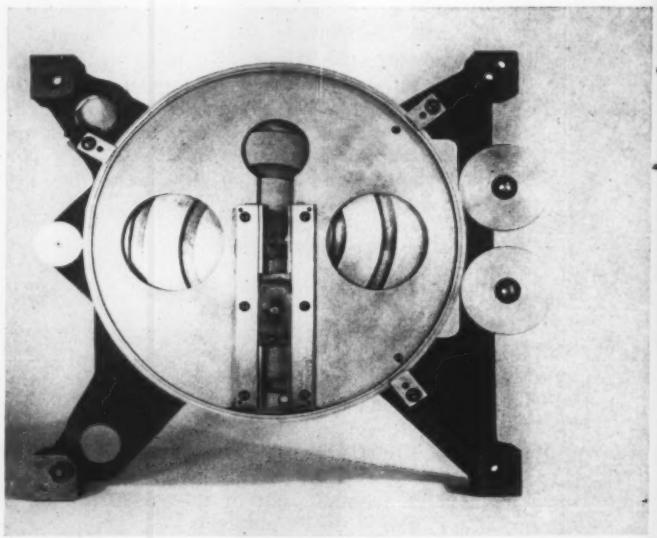


Fig. 27—Cam-type component solver

However, for special applications where converting to electrical parameters is difficult, mechanical component solvers are advantageous.

Resultant Solver: Reverse operation of the component solver may be required to compute the radius ρ and angle θ from given values of x and y. However, simple reverse operation is not practical because of the presence of dead spots or hang-up points. Follow-up servo control of the components must be added, Fig. 28. Another requirement is a means, such as a cam and switch arrangement for accommodating the different quadrants.

Inputs x and y are compared to component solver outputs x' and y'. Any difference is converted to an electrical analog by potentiometers, synchros, or switches which function as the comparators. Differences between x and x' or y and y' cause an electrical error signal which is fed back to the servo motor. The motor responds to diminish the error. When the x and x' values are equal and the y and y' values are equal, the indicated ρ and θ values are the solution.

The quadrant switch gives adequate control of the ρ and θ servos. Depending upon where the resultant lies, differences in x values and y values should control ρ and θ respectively; or, reversed, to servo rapidly and smoothly to a null and solution. A simple analysis would show that switching should occur approximately at the 45-deg axis. In practice, the quadrant switch is mechanically driven by θ. A simple cam and limit switch, as in Fig.

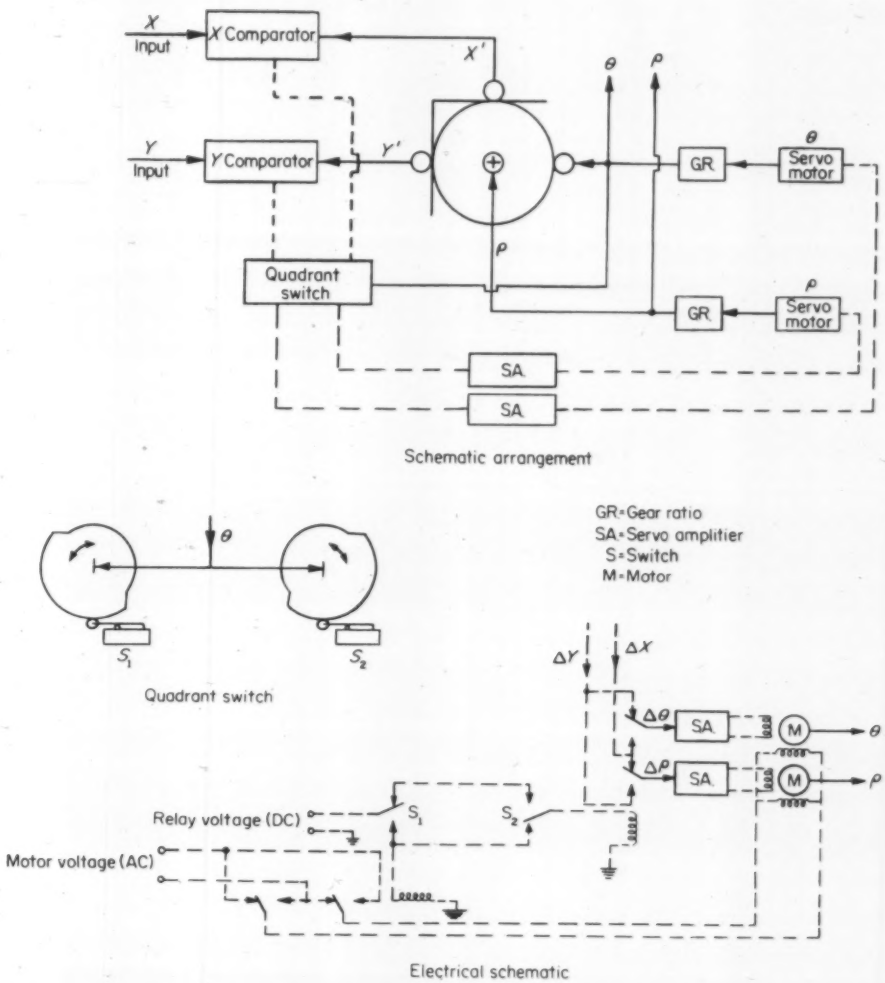


Fig. 28—Resultant solver

28, can activate relays which control the direction of rotation of the servo motors. Error difference (x or y) controls ρ and θ.

Sphere Component Integrator: Resolving an input into sine and cosine components, the sphere component integrator also continuously supplies an analog for convenient integration. Thus, its function is similar to the combination of Scotch yoke and integrator.

Essentially, the unit consists of three discs or rollers and a sphere, Fig. 29. One disc, the input, drives the sphere by friction contact. The sphere, in turn, drives two output discs which have their axes at right angles to one another. The input disc can be swiveled through 360 deg. The two output discs rotate in accordance with the angular orientation of the input disc. Essentials are shown in the elevation, plan, and partial views of Fig. 29. This unit is compact and ingenious, but a high rate of wear occurs at zero output points, as with the ball-and disc integrator.

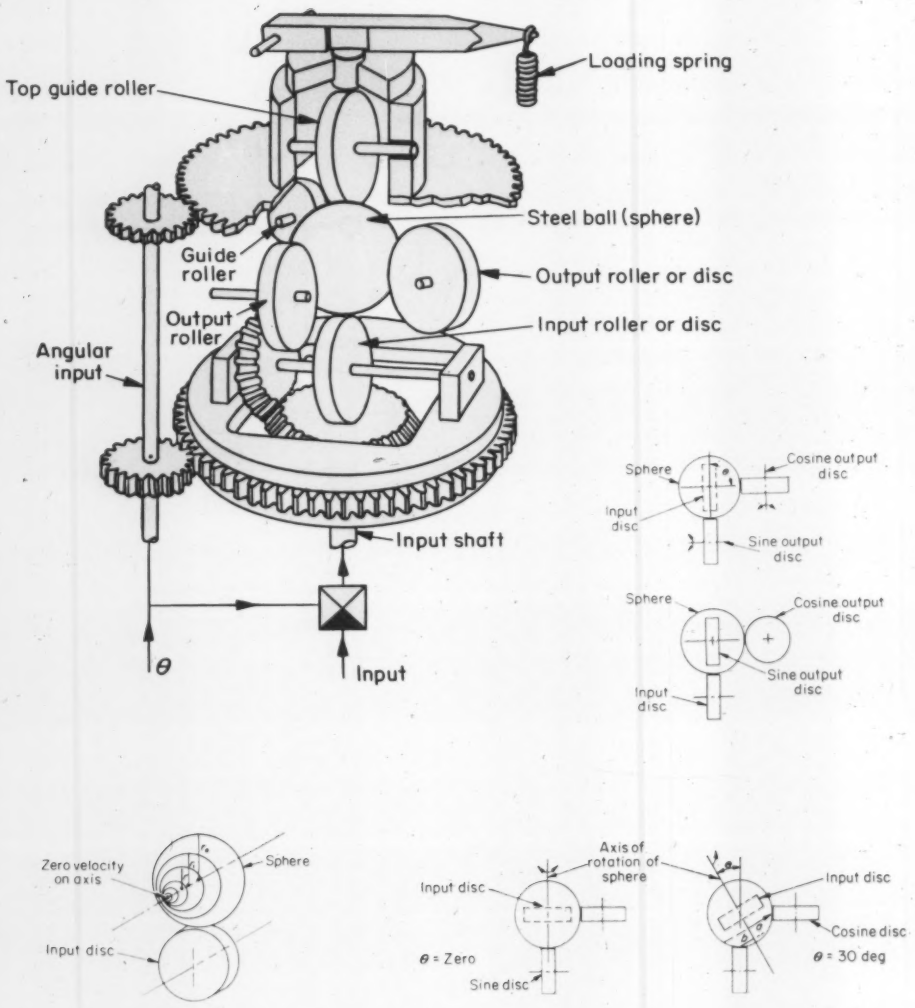
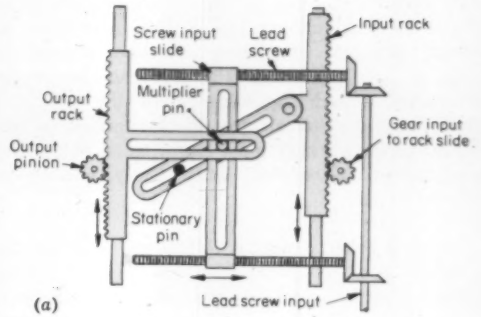


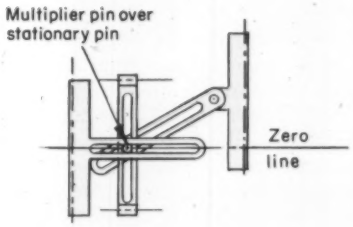
Fig. 29—Sphere-component integrator

Multiplication and Division

Simple gears and levers do simple multiplication —a variable times a constant. Whether output is angular or linear displacement, mechanical ratio in the motion generator equals the constant. Devices which multiply two variables are much more complex, and reversal for division has limitations. Certain multipliers are mechanisms based on simi-



(a)



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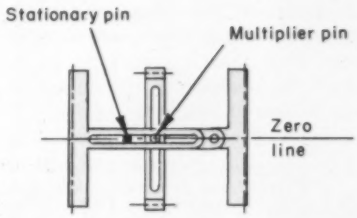

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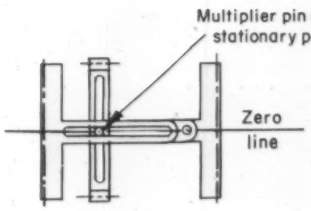

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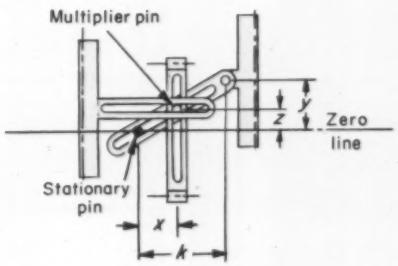

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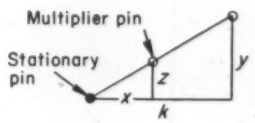

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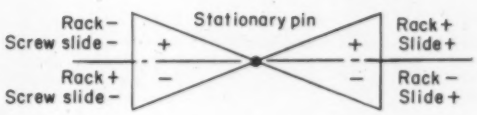


(g)

Fig. 30—Screw-type multiplier

lar triangles. Others include linkages, logarithmic devices, and squaring gears.

Multiplier Based on Similar Triangles

Two input slides are controlled by a lead screw and a rack and pinion pair in the screw-type multiplier, Fig. 30. Output is another slotted slide which drives a pinion through a rack. A multiplier pin engages all three slots and also a stationary pin about which the input rack link pivots.

Positions of the input slides represent values of the two input variables. Answers are represented by output-rack positions.

Zero position of the input slide screw is obtained by turning both lead screws until the multiplier pin is directly over the stationary pin, Fig. 30*b*. When the slide is in this position, the output rack will not move regardless of input motion.

Another condition of no output occurs at zero position of the input rack, Fig. 30*c*. The slot in the input slide pivot arm is positioned coincident or parallel to the slot in the output rack. Both conditions can be set up simultaneously so that both inputs are zeroed, Fig. 30*d*.

If both inputs are given some displacement, Fig. 30*e*, the multiplier assumes a new position related to the two inputs. Note that the screw input slide moves horizontally an amount x, the input rack an amount y, and the output rack up z.

Displacement quantities x, y, and z form two, similar, right triangles, Fig. 30*f*. From the similar triangles, $z = xy/k$ where x is screw-slide input, and y is rack-slide input.

Output product z can be either positive or negative if the input slides are arbitrarily given senses ($+$ and $-$) relative to their respective zero positions, Fig. 30*g*.

Rack-type multipliers are identical to screw types except for input members. Another multiplier is the sector type in which racks and screws are replaced by sector gears and linkages. The sector type operates on the similar-triangles principle. Output values are approximate due to substitution of arc motions for straight line motions.

Dividers

To perform division it should be possible to reverse a conventional multiplier. But there is an important physical limitation. As the divisor approaches zero, the quotient becomes larger and can easily exceed the capacity of the output. A small input motion of the divisor causes a large output. Since work in must equal work out, a huge input torque is required. Quite likely, friction will lock the device.

Dividing with a Servo Follow-up: Another way to divide is to use a conventional mechanical multiplier, a servo motor, and a differential, Fig. 31. If the quotient of X/Y is to be obtained, divisor Y is put into the multiplier with quantity Z. Then output product YZ is put into a mechanical differential where the dividend is subtracted from it. If the difference is not zero, the differential output will position a follow-up control so that a servo motor drives the multiplier input Z until $ZY = X = 0$. At this point, motor drive control is neutral, and $X/Y = Z$. The solution is the quotient obtained as a take-off from the Z input to the multiplier.

Reciprocal Method: The quotient of X/Y can be obtained by computing the reciprocal $1/Y$, then obtaining the product $(1/Y)X$ by means of a conventional multiplier. This approach is suitable only if the reciprocal can be obtained readily, as by cams or reciprocal trigonometric functions.

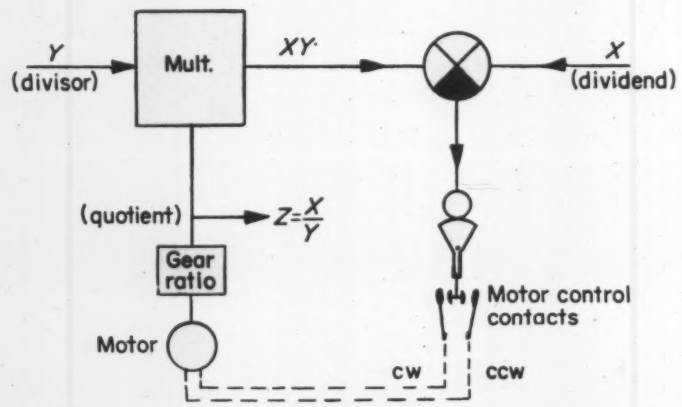
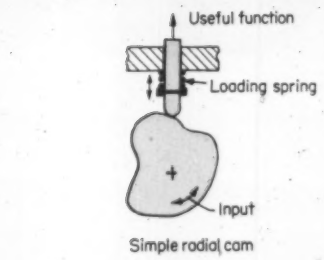
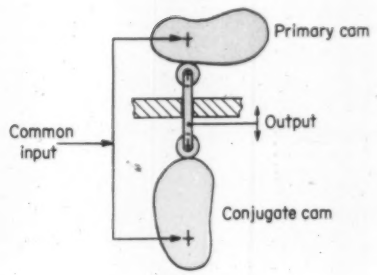


Fig. 31—Schematic of divider using servoed multiplier

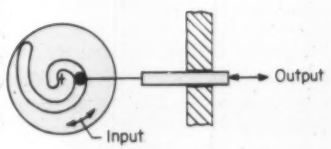
Computing Cams and Gears



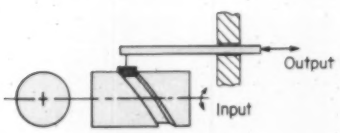
Simple radial cam



Conjugate radial cams

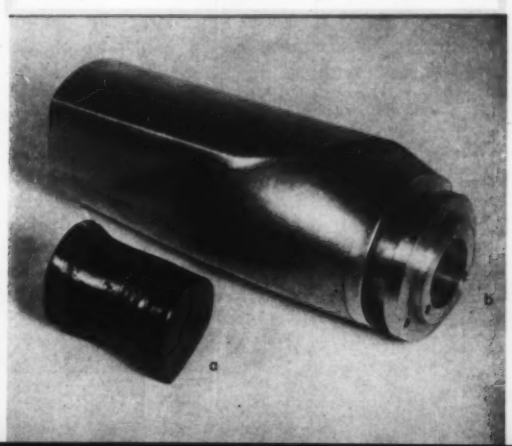


Radial groove cam



Cylindrical axial cam

Fig. 32—Cam types for computers



Mechanisms discussed so far produce unique and relatively simple mathematical functions. However, at times it is necessary to compute much more complicated functions, some of which would be cumbersome as mathematical equations.

For example, consider a computer which requires the earth's surface elevation above sea level as an input. Presumably, there is a function relating elevation to longitude and latitude, but imagine how complicated this function must be! Fortunately, elevation has been determined for most areas of the earth and this information exists in geodetic survey tables. The easiest method of providing the elevation function is to build a computing cam based upon the known data. Thus, the cam will be a physical replica of the function—an analog of the earth's surface.

Cam Designs and Features

Two general types of cams are recognized for computer applications: 1. Single degree of freedom, that is, $y = f(x)$. 2. Two degrees of freedom, having two variables, that is, $z = f(xy)$. Subtypes in the first group, Fig. 32, include: Simple radial plate cam, conjugate cam, radial groove cam, cylindrical axial cam. The second major type includes the barrel or three-dimensional cam, Fig. 33.

Certain design considerations apply particularly to computer applications: 1. Profiles and all parts require high precision. 2. Friction should be minimized by use of rolling elements rather than sliding. 3. In the interest of accuracy, speeds should be low.

Function Gears

Circular gears are commonly used for transmitting linear position with the gear ratio being merely a change in scale factor. Gears with noncircular pitch lines, such as elliptical and spiral, can be used for generating mathematical functions. The major problem encountered is the special machine attachments and controls necessary for generating and inspecting noncircular gears.

Types of Function Gears: Four types are recognized, including:

RADIAL GEARS: These are similar to circular gears except that their pitch line is noncircular. Fig. 34

Fig. 33—Three-dimensional barrel cams: *(a)* Variation of earth's magnetic north. *(b)* Ballistics computation data

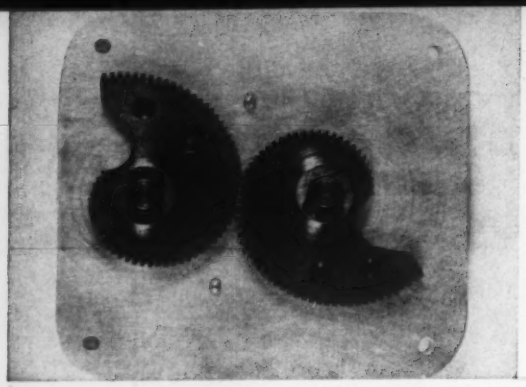
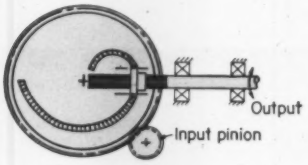


Fig. 34—Radial function gears

Fig. 35—Spiral-face function gear



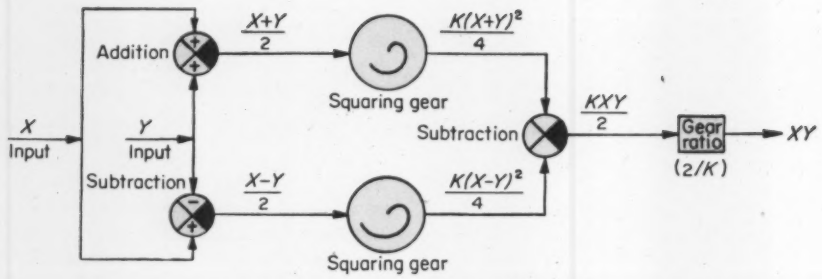


Fig. 36—Quarter-squares multiplier

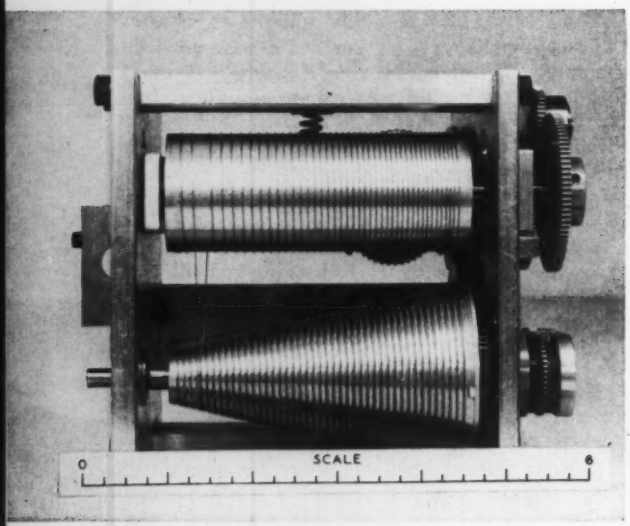


Fig. 37—Helicoidal surface squaring mechanism. Photo, courtesy Librascope, Inc.

shows a logarithmic pair. Radial gears can be made in many function forms such as elliptical, exponential, and spiral. For best performance, two conditions must be achieved: 1. Sum of pitch radii for any position must be constant. 2. Contact point must always be on the line of centers.

Spiral Face Gears: Face gears have been made to produce functions by modifying the pitch line into a spiral form, Fig. 35. The pictured unit, which uses a spiral of Archimedes, is a squaring device. That is, output = input squared.

Squaring Gear Multiplier: Two squaring gears, combined in a manner originated many years ago by Gaus, produce a quarter-squares multipliers, Fig. 36. In addition to the two squaring gears, this unit requires three differentials, a gear box, and interconnection gearing. The mathematical principle of the quarter-squares multiplier is

$$xy = \frac{1}{4}(x+y)^2 - \frac{1}{4}(x-y)^2$$

Helicoidal Function Gears: Computing gears have also been designed employing teeth placed on helicoidal surfaces instead of planes. Squaring units have been made in this manner. Because of the difficulty in producing gear teeth in a continuous spiral on a conical surface, a variation is the "toothless" squaring mechanism, Fig. 37. In place of gear teeth, this unit employs a wire drive which is constrained to follow a helicoidal groove.

Fabrication of Function Gears: The use of function gears has been limited due to their involved design and even more due to the difficulty of fabrication. In recent years, numerical servo-controlled machines have made these gears rapidly, accurately, and cheaply. The use of electronic digital engineering calculators has greatly reduced the engineering design time.

Linkages

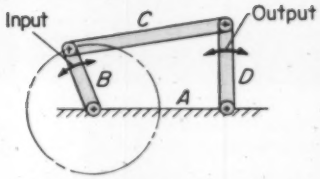


Fig. 38—Basic four-bar linkage

Addition, multiplication, squaring, and trigonometric functions can be performed by linkages. They can be used also to approximate complicated functions which might not be feasible by other mechanical designs except, perhaps, cams. Because

Fig. 39—Typical linkage computer

Photo, courtesy Librascope, Inc.

of the many functions for which they can be used, entire computing systems can be true linkage computers.

Linkage mechanisms consist of rigid elements connected by simple turning or sliding pairs. A fundamental assembly from which more complicated systems are built is the four-bar linkage, Fig. 38. If one link is fixed, rotation of another is considered an input, and rotation of an opposite link is the output. Various motions are obtained for points on the links. Various motion functions can be obtained by varying each of the four links. Mechanisms which are solutions for mathematical equations can be obtained by properly combining four-bar linkages and slide links. Many linkage motions have been catalogued and published.

Combinations of four-bar elements can generate an almost inexhaustible number of functions. In particular, cam functions can be duplicated by linkage systems. A typical linkage computer is shown in Fig. 39.

Advantages: Linkages should be considered for the following reasons:

1. Simple links with bearing joints are relatively easy to make, and with high precision.
2. Small errors in link lengths have relatively little effect on function accuracy.
3. Design can be compact with relatively thin laminar units.
4. Since linkages offer a powerful solution technique, they can be applied to the most complicated computer problems.
5. Because of rotating pairs, as compared to sliding pairs, linkages are more efficient than many other forms of mechanisms.

Limitations: Along with their virtues, linkages have several disadvantages:

1. Design time is great if trial-and-error methods are used; otherwise, more direct methods require familiarity with rather sophisticated techniques.
2. Unless production is high, low fabrication cost is offset by high engineering investment.
3. For high-speed applications, the inertia of links causes dynamic forces.

Error Analysis

Errors in computers are designated A, B, or C, according to a system established years ago by the Navy Bureau of Ordnance.

Class A errors are all deviations from physical perfection. These include manufacturing tolerances, assembly error, and imperfection in adjustments and settings.

Class B errors are theoretical departures from perfection. They include invalid assumptions intended to simplify mathematical treatments of problems. Class B errors also occur when computer systems are not theoretically perfect analogs of problems.

Class C errors originate outside the computer as part of the input. Input assumptions may not be true expressions of input conditions.

In the design stage, only Class B errors can be predicted with any degree of accuracy. They result directly from the designer's decisions of approximation and simplification. Class A errors can be predicted with somewhat less accuracy. The prediction technique is statistical.

Sound practice calls for error analysis as a part of the design procedure. Analysis requires knowledge of the Class B errors and an estimate of the Class A and C errors. Although such analyses include substantial "guess information," an overall error figure will go a long way toward verifying the design prior to expenditures for fabrication and test.

No one procedure can be prescribed, but in a general approach, every conceivable Class A, B, and C error can be listed and probable values, or range of values, can be assigned.

Then, error combinations must be determined and net errors obtained. The estimate of probable error values and the combinations of errors may become a complex problem requiring statistics and higher mathematics. Nevertheless, for any given computer system, meaningful error figures can be obtained. Usually, the probable errors are sought, since maximum error totals are usually unrealistic. Error analyses should be made early in the design and continued through all modifications.

Computer System Synthesis

In the development of a computer system, the initial task is to formulate a schematic solution. Since the best possible design is desired for the known circumstances, the designer must consider all types of solutions.

A design aid for this purpose is a block schematic. It begins with given inputs, ends with desired outputs, and shows in-between operations as only functional blocks with no indication of how the answer can be reached. With this skeleton, various approaches to solution can be compared. Methods examined should include all applicable mechanical, electromechanical, and electronic techniques.

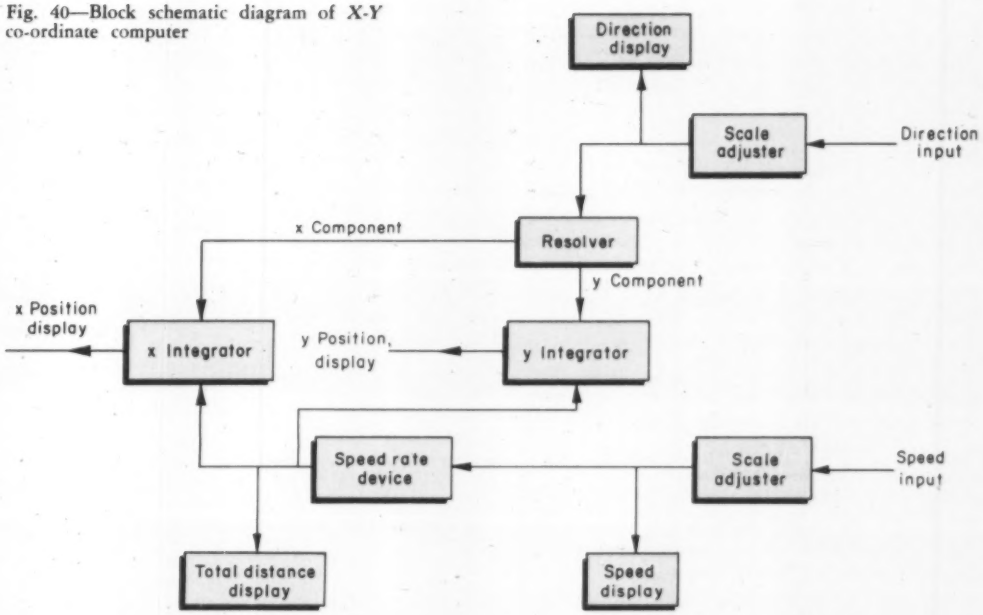
The next step is preparation of a detailed schematic. It will fully specify computing components, component accuracies, scale factors, gear ratios, critical noncomputing elements, driving power sources, input data, output displays, and intelligence. Physical layout and packaging follow the detailed schematic.

Computer Example

The position of an object moving in an x-y plane is to be continuously computed in terms of x and y co-ordinates. The co-ordinate positions are to be displayed on counters, the instantaneous heading is to be displayed on a 360-deg dial, and the instantaneous speed is to be displayed to the nearest mile on a counter. Total distance traveled is to be shown on another counter.

The input information is in the form of two

Fig. 40—Block schematic diagram of *X-Y* co-ordinate computer



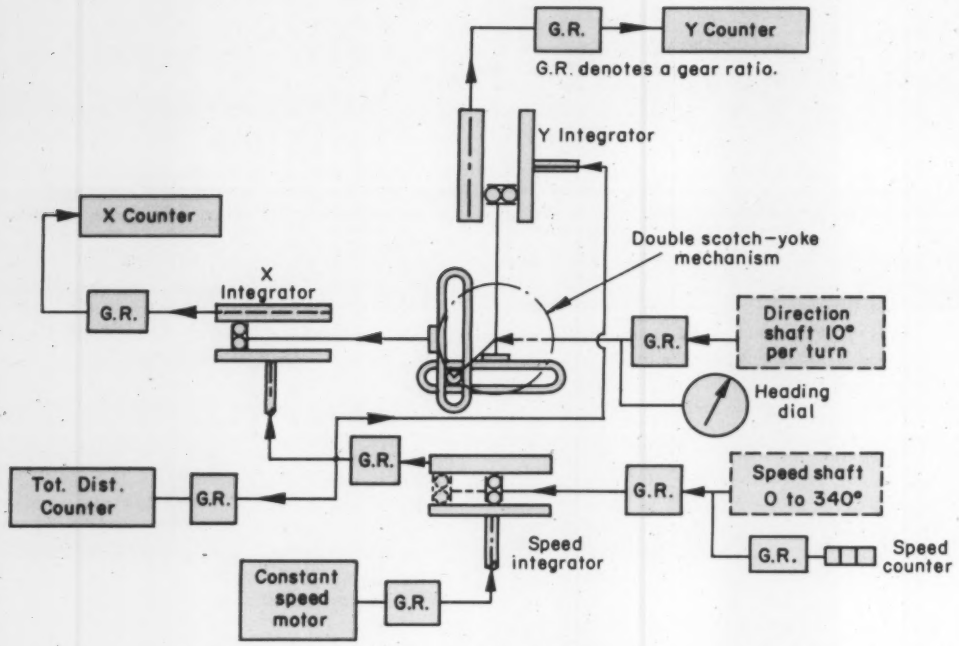


Fig. 41—Schematic of *X-Y* co-ordinate computer

shaft inputs: Instantaneous speed and direction of motion. The direction shaft has a scale factor of 10 deg per turn. Speed range is zero to 100 mph, co-ordinate counter capacity is to be ±500 miles, total disance capacity is to be 10,000 miles, accuracy ±1 per cent.

The first step is to list all the required basic computations in the form of a block schematic diagram. The advantage is that each computation or manipulation of data is presented in logical sequence. The block diagram is a replica of the flow of information and operations. For this problem, the schematic is Fig. 40.

Solution requires only two types of mathematical operations: Resolution into co-ordinate components, and integration. The balance of the computer manipulations are merely scale factor adjustments and display elements. The next step is arrangement of computing components and selection of "hardware."

One combination of components is shown in Fig. 41. This solution involves: a double Scotch yoke for resolution, a ball-and-disc integrator to provide the variable-speed analog, and two ball-and-disc integrators for integration of the x and y positions. The diagram also indicates necessary gear boxes for achieving proper scale factors and optimum speed of operation. Consideration has been given to amplification of torques to insure sufficient power for reliable operation. For example, since ball-and-disc integrators are low-output devices, gear reductions to amplify the output torque are provided.

Fig. 41 is incomplete; it should be further refined with the addition of exact gear ratios, scale factors, specific component identification, and performance accuracies. The final schematic would then represent a design that could be transformed into a physical product.

Achievement of specified accuracy must be verified by preparing an error analysis of the system. It should include all Class A errors. Since the chosen components are theoretically perfect mathematical solutions, there are no Class B errors. Class A errors in the components, and gearing errors, are the principal ones.

The Future

Present and future roles of computing mechanisms are likely to be somewhat different than suggested by a mere projection of their past.

Between the two world wars, mechanical analog computers reached their zenith in gun-fire control and navigation. Actually, these computers were electromechanical. They contained synchro and potentiometer servos with power amplification.

Today, an all-mechanical computer is a rarity.

Much of the work of even the electromechanical computer has been taken over by electronic analogs and digital computers. But there remain areas of present and future applications that can be best served by mechanisms in computing systems.

In computers that are principally electrical or electronic, mechanical components are often best for performing certain functions.

Also, special-purpose tasks, such as those involving the physical handling of materials, are prime applications.

For example, automation often requires geometric motions and positioning of work. Solving the problem abstractly by electronics is indirect, if the final objective is performance of a physical function. An electromechanical computer can often do both jobs simultaneously.

Directness of solution, ruggedness, and reliability may often be the factors that influence choice of the mechanisms surveyed in this article.

ACKNOWLEDGMENT

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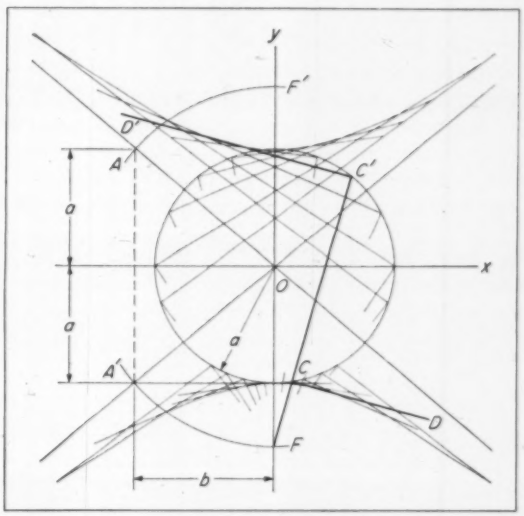
Tips and Techniques

Hyperbola Construction

When the equation of a hyperbola is in the form $(y^2/a^2) - (x^2/b^2) = 1$, the hyperbola can be quickly and accurately constructed by this method:

1. Construct x and y axes intersecting at O.
2. Draw a circle with radius a and center O.
3. Locate points A and A' with co-ordinates $x = \pm b, y = \pm a$.
4. Locate points F and F' on the y axis so that $OF = OF' = OA$.



5. Draw a line from F that cuts the circle at two points C and C'. This line can be drawn from F' also.
6. Draw lines CD and $C'D'$ perpendicular to line FC'.
7. Repeat steps 5 and 6 to obtain a number of these lines.
8. Construct the hyperbola by drawing curves which are tangent to each of the CD and $C'D'$ lines.

—BYRON M. ROBINSON, *design engineer, Sutton Engineering Co., Bellefonte, Pa.*

EDITOR'S NOTE

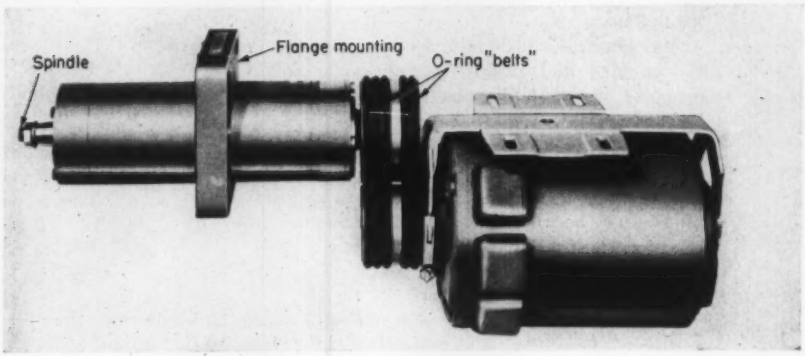
Another method for hyperbola construction is described in the May 15, 1958 issue of MACHINE DESIGN on page 118.

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

O-Rings Drive High-Speed Spindle in

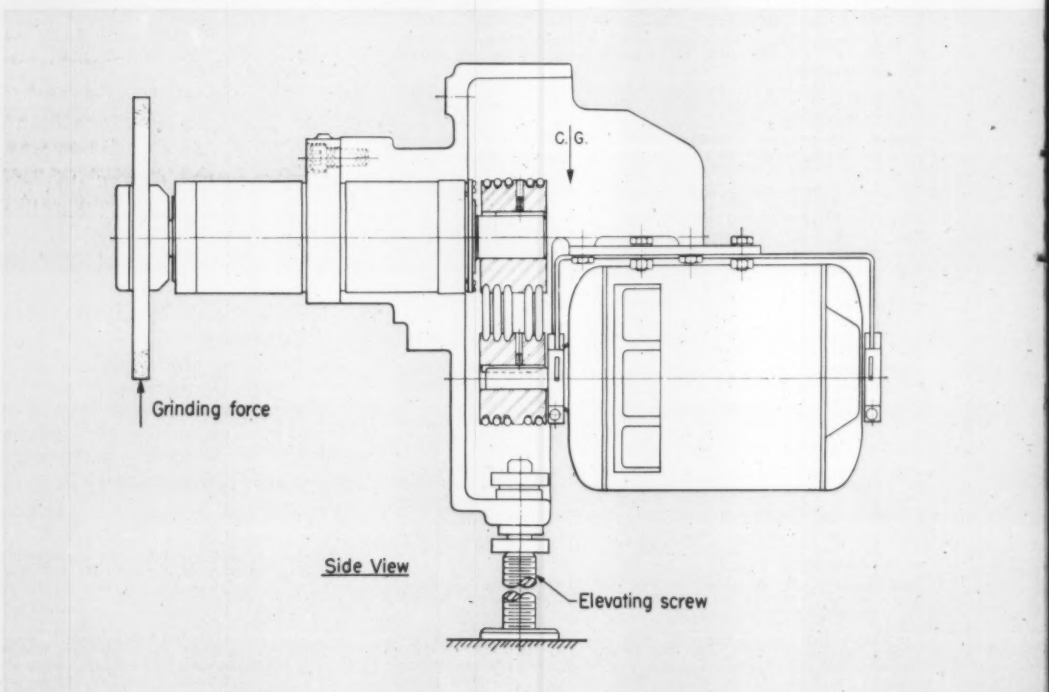
SHORT-CENTER "BELT" DRIVE to the spindle of a new surface-grinding machine consists of five O-rings which are 1/4-in. in diameter with a 5 1/8 in. OD. These belts are made of Grade 830 synthetic rubber and have a durometer hardness of 70. The belts are mounted with an 11 per cent initial stretch. After a test run on the machine of 860 hr or 154,000 cycles, these belts showed no signs of wear. As reported by Emile Couture, Brown & Sharpe Mfg. Co., Providence, R. I., O-rings were selected for this application because of size and length uniformity and jointless design.

Short-center drive design holds down over-all machine height. This feature also minimizes bow-out of the O-ring belts when loads are applied. A 3600-rpm, 1-hp motor is mounted in a resilient cradle-type mount to further reduce vibrations.

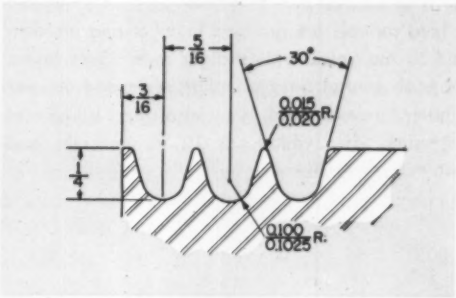


TWO-PLANE BIASING of the sliding wheel-head member eliminates any movement when loads are applied to the grinder. This design objective is met in one plane (side view) by placing center of head elevating screw forward of the center of gravity, preventing wheel-head tilting when load is applied.

Sliding looseness in the other plane (front view) is also removed by mounting the elevating screw off the center of gravity, tilting the head counterclockwise. To prevent any possibility of the head hanging up and rocking when it is fed down, two Teflon spring-loaded plungers are mounted in the head.

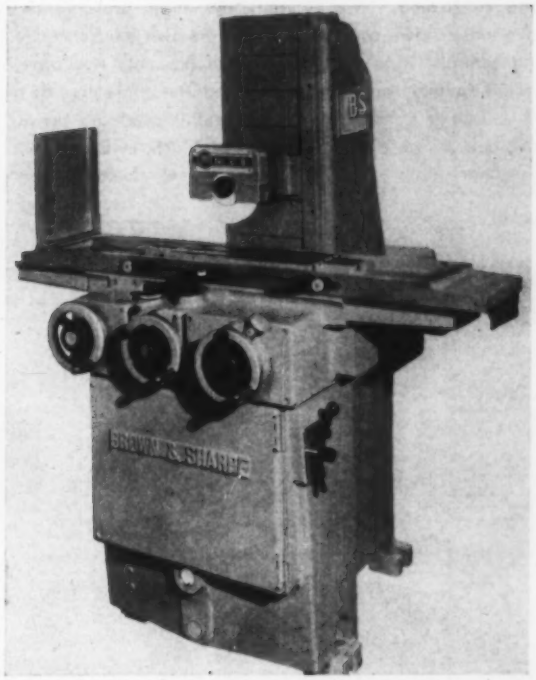


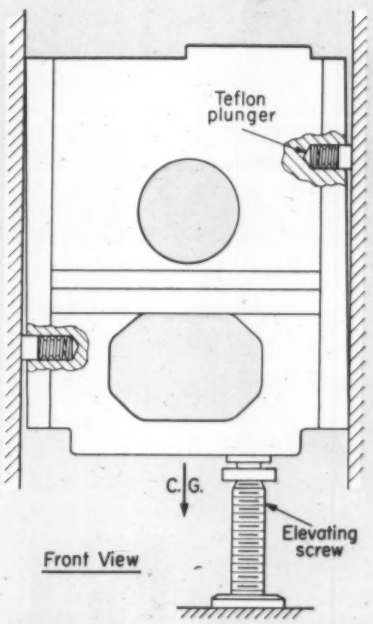
Hydraulically Controlled Grinding Machine

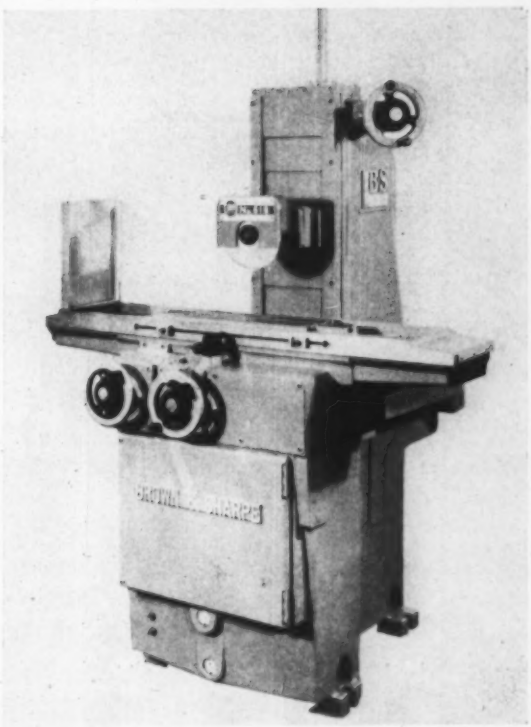


TAPERED-SIDE SHEAVE GROOVES were found most suitable for these O-ring belts.

EYE-LEVEL OR HIP-LEVEL OPTION is provided in the design for the location of head-elevating handwheel on these two new 618 machines.





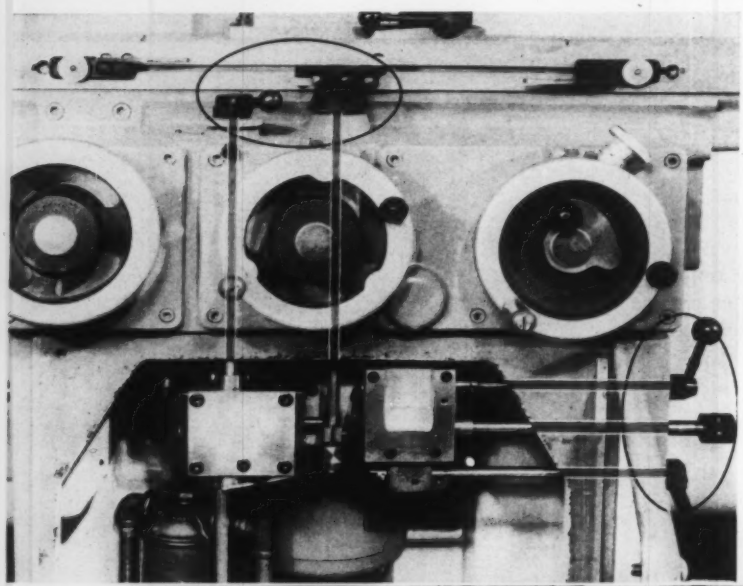


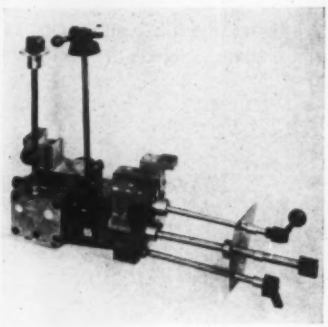
Hydraulically Controlled Grinding Machine

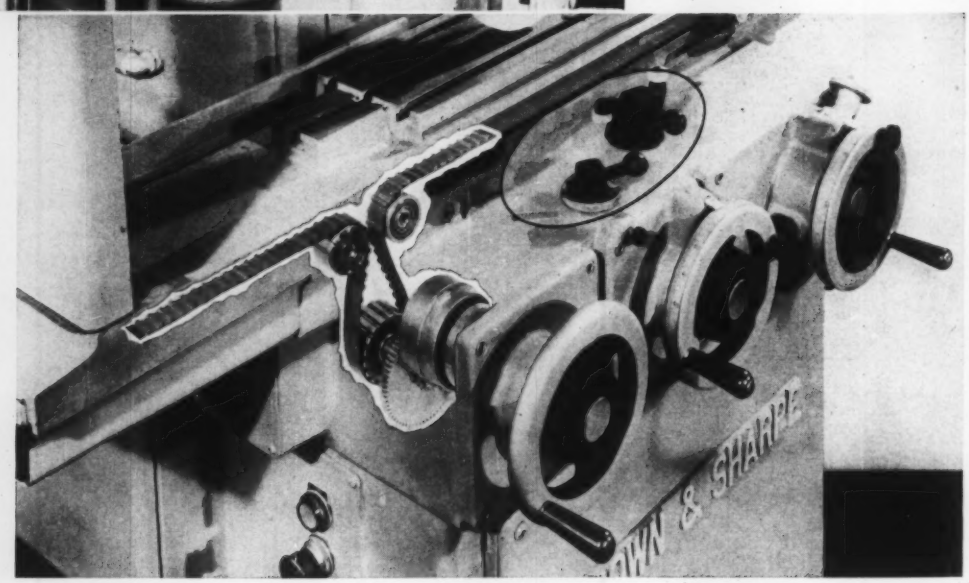
HYDRAULIC OR MANUAL POWER can be used for table and cross feed. The hydraulic system is broken into two independent circuits, each with its own interconnecting controls. The table-feed circuit has only two controls—the reversing mechanism and the table throttle.

Unusually smooth table movement is produced by a cog belt, which operates without backlash, in the hand-actuated table drive. The handwheel automatically disengages through a cone clutch when power is applied.

Cross-feed controls are grouped together and are also connected to the valve with straight rods. Two levers and one knob control direction of traverse and amount of intermittent traverse feed; they also select truing and fast-positioning rates which are 10 in. per min and 12 ft per min, respectively.



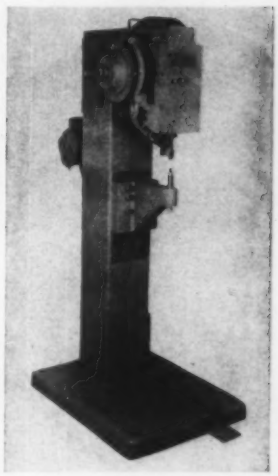


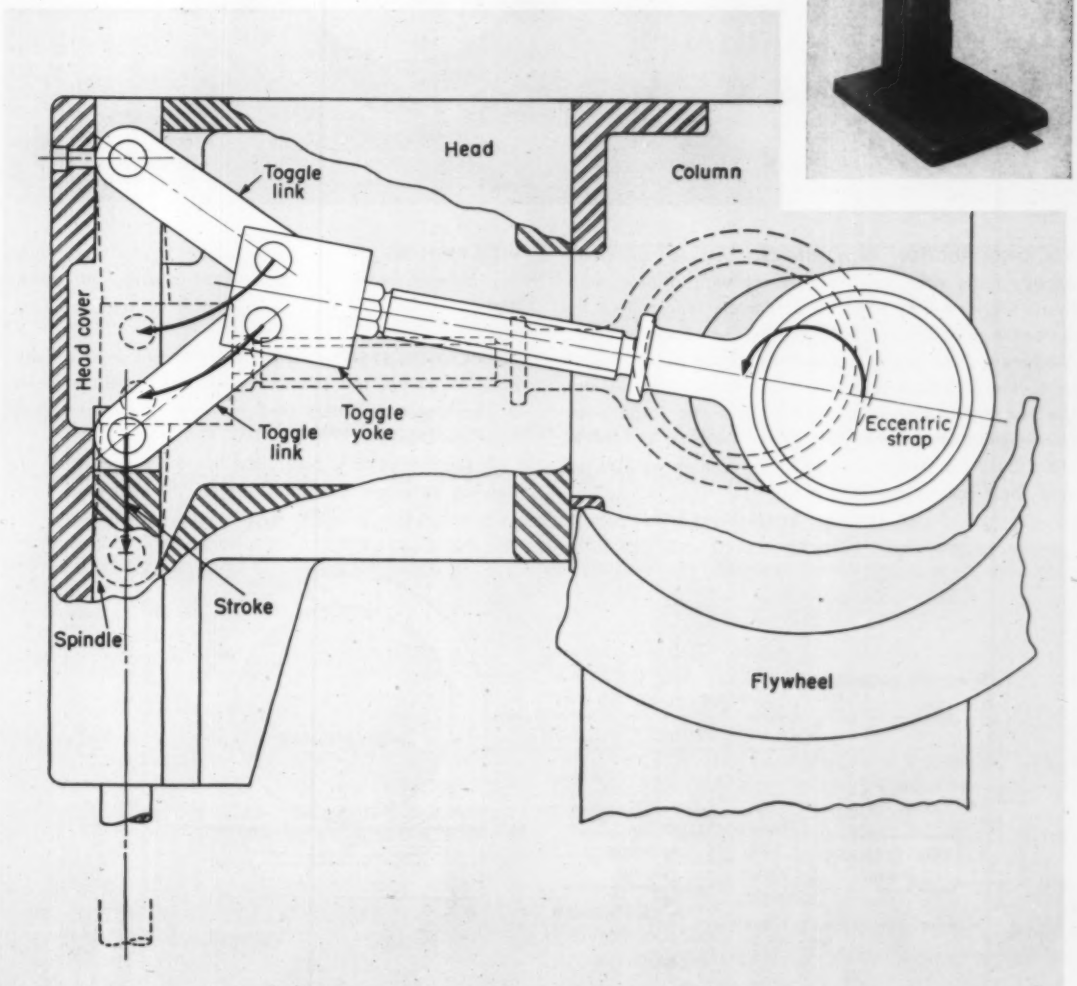


Eccentric and Toggle Combine To Develop High Forces

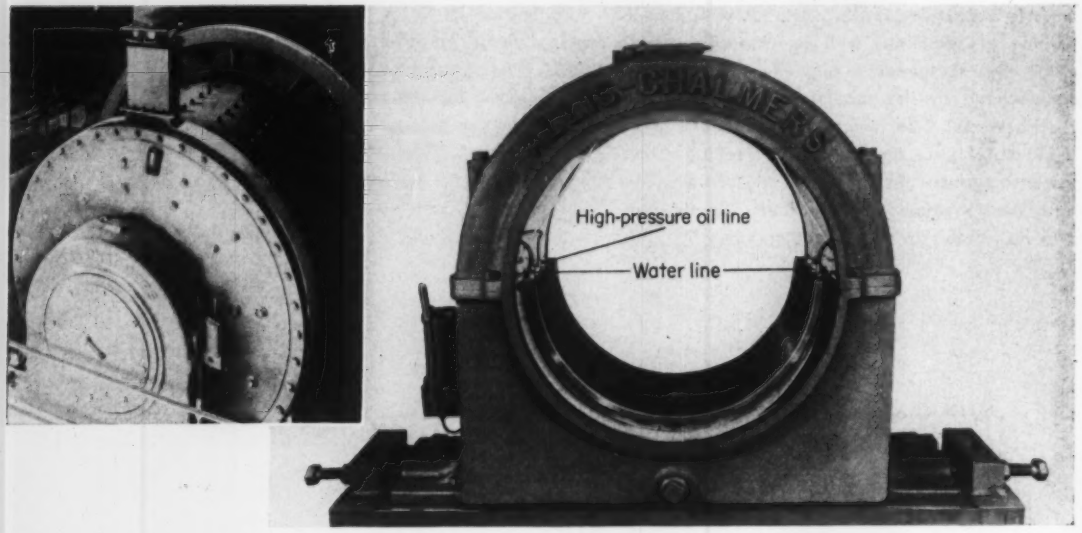
REPETITIVE HIGH-PRESSURE SQUEEZES with minimum vibration and jar to the machine are produced with an eccentric-actuated toggle linkage of novel design. The mechanism is applied in the new Model 110A riveting machine manufactured by the Tubular Rivet and Stud Co., Quincy Mass. According to John Wessel, chief engineer, the eccentric and toggle linkage can produce 10,000 lb of force through the rivet-setting range.

In operation, the centers of the pivots in the toggle yoke do not quite reach the centerline of the spindle. The flywheel is driven at 150 rpm by a ½-hp, 1140-rpm electric motor.





Lubrication System Automatically Floats Heavy Shafts at Low Speeds

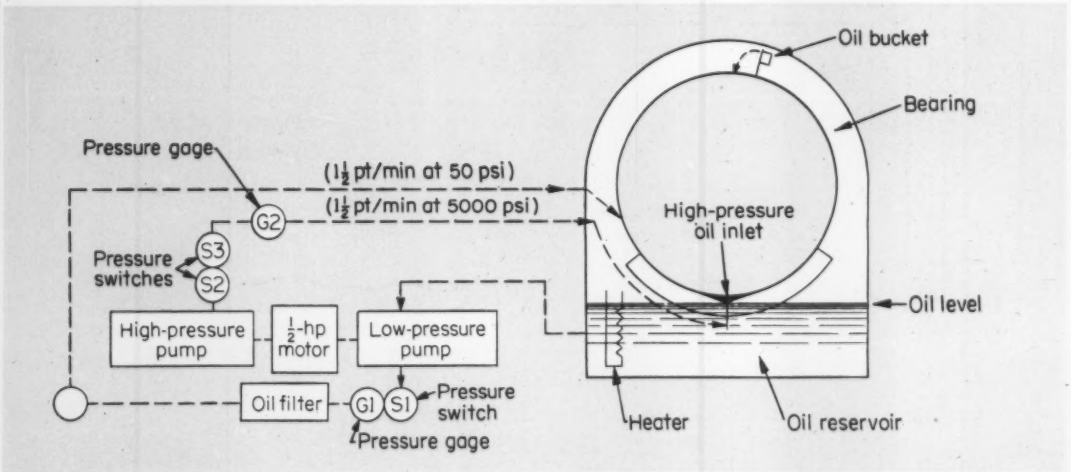


STARTING FRICTION IS MINIMIZED between extremely heavy shafts and bearing surfaces with a new automatic lubrication system. E. J. Klovers reports that the system was developed by the Allis Chalmers Processing Machinery Dept. for grinding mills where bearing loads in excess of 200 tons are not uncommon. In this mill, the bearing areas under each end of the large cylindrical grinding chamber are about 1400 sq in. (54 in. diam by 26 in. length). Loads are as high as 300 psi, and shaft speeds are only 4 fps.

HIGH-PRESSURE OIL is automatically forced up through the bottom center of the sleeve bearing to reduce friction by literally floating the shaft on oil.

LUBRICATION-SYSTEM COMPONENTS consist of a high-pressure pump, low-pressure pump, ½-hp drive motor, a cartridge-type filter, and suitable gages and pressure switches.

A thermostatically controlled immersion heater in the bearing reservoir maintains proper oil viscosity.



By JOSEPH KAPLAN
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and

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Senior Engineer

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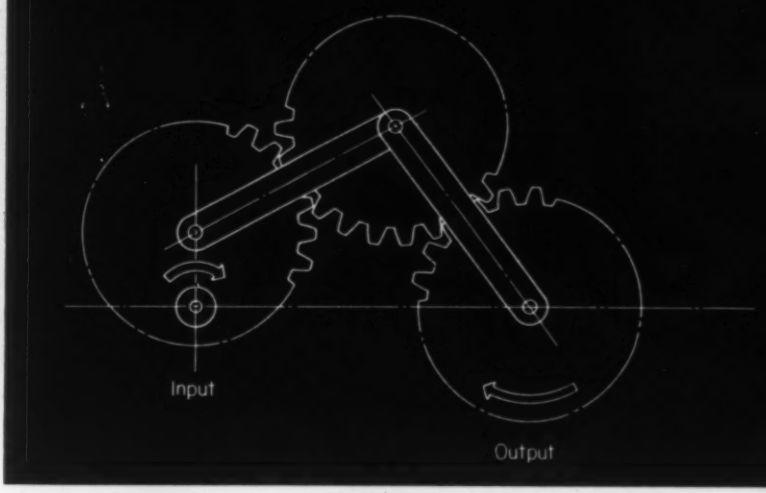
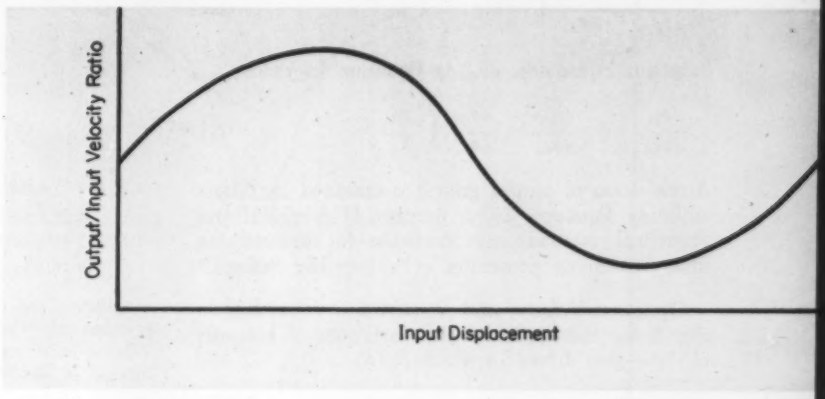


Cyclic Three-Gear Drives



Speeding up and slowing down, cyclically—that's the characteristic output of a three-gear drive driven at constant speed.

But designing for the desired range of variable output speed is not simple. Besides the gear dimensions, the right combination of link lengths must be selected.

Procedures for finding optimum proportions are outlined here.

ESSENTIALS of a three-gear drive are an output gear, an idler gear, and a drive shaft fixed eccentric to an input gear. The gears are joined by a four-bar linkage of which the input eccentric is one member. If input to the assembly is constant angular speed, characteristic output is cyclic angular speed. This performance enables the drive, for example, to couple inertia loads with a minimum of shock. Ensuing benefits are realized in the form of smoother machine operation, longer machine life, and higher cycling rates.

One cycle of the assembly is equal to one revolution of the input shaft. The revolutions per cycle of the output shaft equals the ratio of the pitch diameters of the input to output gears. The direction of the cyclic output displacement is the same as that of the input.

In this article, kinematic equations for a three-gear drive are based on corresponding expressions for a planetary drive and a four-bar linkage.

Kinematic Performance: The output from gear 3 is the same as that from a planetary drive in which gear 3 is the sun and gear 2 the planet. As derived in textbooks, the motion of the sun gear 3 is

$$d\theta_{3a} = -d\theta_{ca} - d\theta_{2c}\left(\frac{R_2}{R_3}\right) \quad (1)$$

Rotation of output gear 3 relative to the input shaft is

$$\frac{d\theta_{3a}}{d\theta_{da}} = -\frac{d\theta_{ca}}{d\theta_{da}} - \frac{d\theta_{2c}}{d\theta_{da}}\left(\frac{R_2}{R_3}\right) \quad (1a)$$

where $d\theta_{ca}/d\theta_{da}$ is the velocity ratio of cranks c and d in the four-bar linkage $abcd$. The ratio $d\theta_{2c}/d\theta_{da}$ is caused by relative rotation of link b about the center of the input gear. From Fig. 1,

$$d\theta_{2c} = d\theta_{db}\left(\frac{R_1}{R_2}\right) \quad (2)$$

$$\frac{d\theta_{2c}}{d\theta_{da}} = \frac{d\theta_{db}}{d\theta_{da}}\left(\frac{R_1}{R_2}\right) \quad (2a)$$

Substitution for $d\theta_{2c}/d\theta_{da}$ in Equation 1a yields

$$\frac{d\theta_{3a}}{d\theta_{da}} = -\frac{d\theta_{ca}}{d\theta_{da}} - \frac{d\theta_{db}}{d\theta_{da}}\left(\frac{R_1}{R_3}\right) \quad (2b)$$

Acceleration of output gear 3 is obtained by differentiating Equation 2b. A number of graphical and analytical methods are available for determining other kinematic properties of a four-bar linkage.*

Optimum Velocity and Acceleration: Illustrated in Fig. 2 are the cyclic velocity variations of a family of three-gear drives for which $R_1/R_3 = 0.5$, 1.0, and

*J. Kaplan and B. Pollick—"Kinematic Analysis," MACHINE DESIGN, Vol. 26, No. 1, Jan., 1954, pp. 153-160.

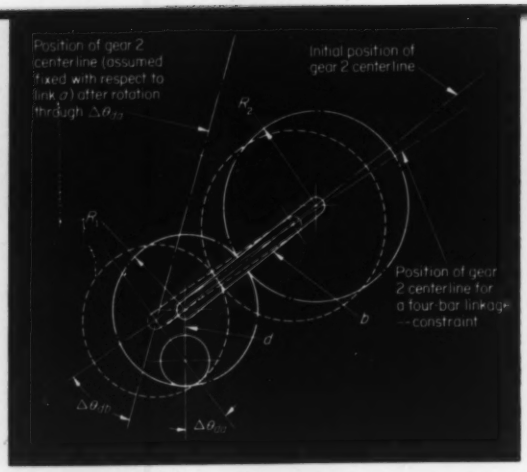
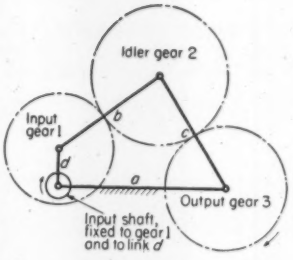

Position of gear 2 centerline (assumed fixed with respect to link a) after rotation through Δθ2a
Initial position of gear 2 centerline
R2
R1
Position of gear 2 centerline for a four-bar linkage constraint
b
d
Δθ1a
Δθ2a

Fig. 1—Input members as a planetary pair

Nomenclature



a, b, c, d = Link designations; also lengths of links
R = Gear pitch radius
1, 2, 3 = Gear designations
θ = Angular displacement

Alphabetical and numerical designations, above, are also used as subscripts. Compounded, they identify members between which relative motion is reckoned. Thus $d\theta_{3a}$ is the increment of displacement of gear 3 with respect to link a.

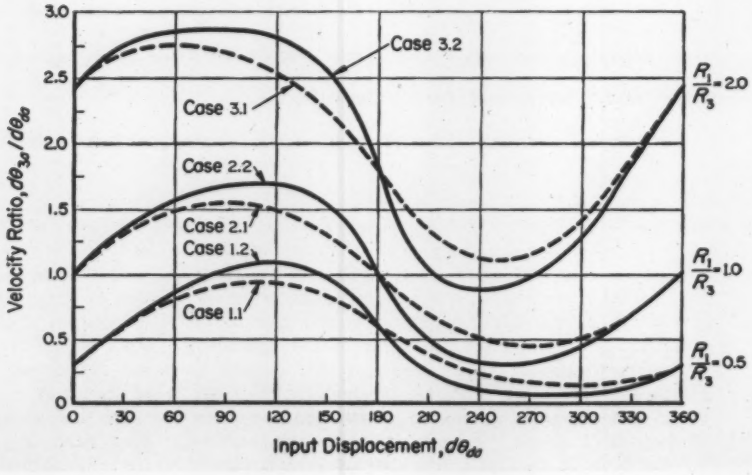


Fig. 2—Velocity characteristics of output gear 3 for three values of R_1/R_3. Case designations 1.1 to 3.2 identify combinations of linkage dimensions from Table 1. Dotted curves indicate optimum performance

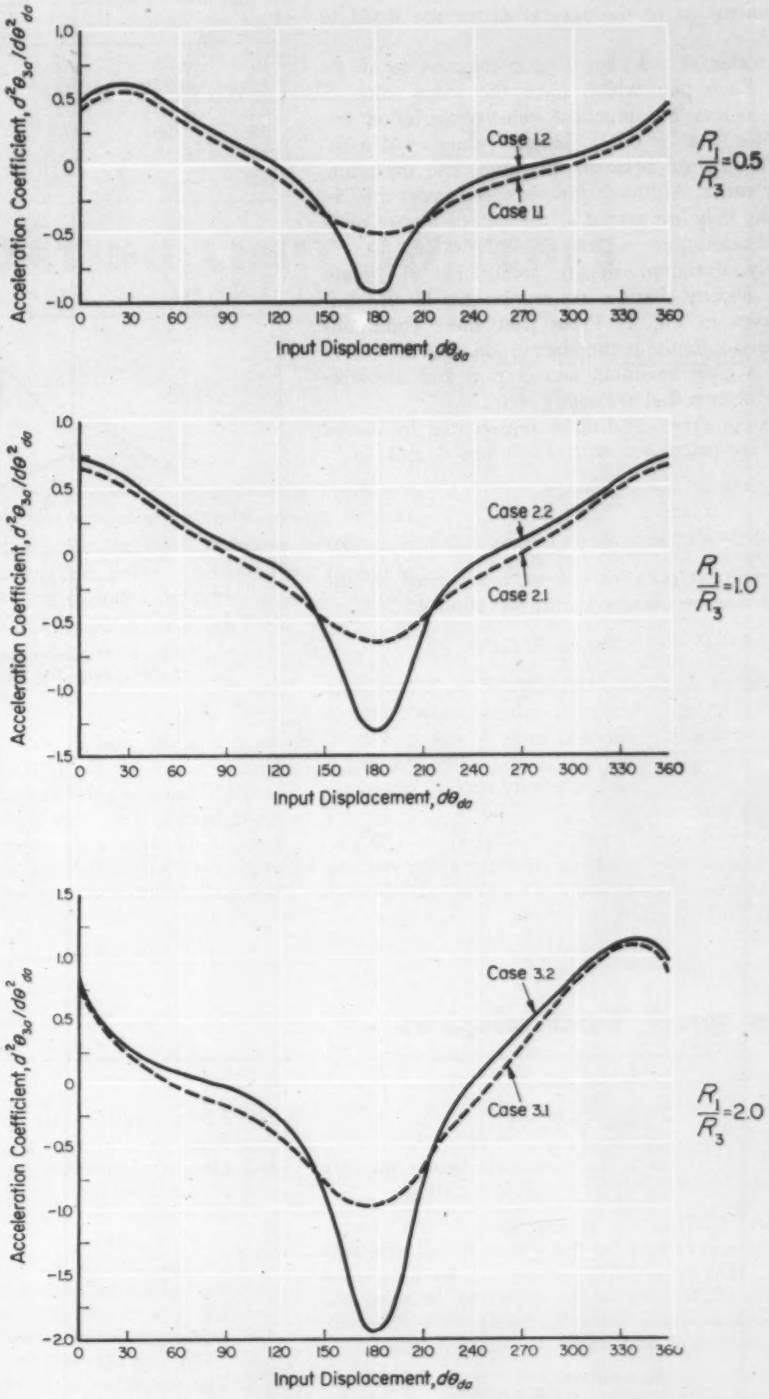


Fig. 3—Acceleration characteristics of output gear 3 for three values of R_1/R_3. See Table 1

2.0. Dimensions of the several drives are listed in Table 1.

The value of the ratio d/a is common to all six curves. Each pair which have the same value of R_1/R_3 enclose the practical velocity variation envelope for $d/a = 0.295$. Larger values of d/a increase the spread between minimum and maximum velocity ratios. Although greater speed ratios may be desirable, they are gained at the cost of higher maximum decelerations, which are undesirable.

Nearly optimum design conditions to obtain smooth velocity changes are represented by the dotted curves in Fig. 2. Proof that these conditions are nearly optimum is the observation that the curves in Fig. 3 give maximum acceleration and deceleration coefficients that are nearly equal.

Optimum drive conditions, represented by dotted curves, are calculated with Equations 3 and 3*a*:

$$(a - d)^2 = b^2 + c^2 - 2bc \cos \theta_{bc} \quad (3)$$

$$(a + d)^2 = b^2 + c^2 - 2bc \cos (180 \text{ deg} - \theta_{bc}) \quad (3a)$$

Maximum velocity variations, represented by the solid curves, are obtained with Equation 4:

$$(a + d)^2 = b^2 + c^2 - 2bc \cos 150 \text{ deg} \quad (4)$$

The terms θ_{bc} and (180 deg $-$ θ_{bc}) represent the minimum and maximum values, respectively, of the included angle between links *b* and c, Fig. 4. When θ_{bc} is not overly acute, and when the angle (180 deg $-$ θ_{bc}) is not excessively obtuse, kinematic action of the drive is good.

Maximum recommended value for θ_{bc} is 150 deg. Larger angles may result in conditions approaching toggle action. Transmission of large loads through such a drive makes poor conditions worse. Both friction and flexibility of links tend to jam the mechanism. Therefore, the design objectives of minimum pivot friction and link rigidty are particularly important for three-gear drives in which the included angle between links *b* and *c*, in the operating range, is smaller than 30 deg or larger than 150 deg.

Table 1—Dimensions of Certain Three-Gear Drives

Case	R_1/R_3	d	b	c	a
1.1	0.5	1.3	2.706	3.706	4.4
1.2	0.5	1.3	2.447	3.447	4.4
2.1	1.0	1.3	3.244	3.244	4.4
2.2	1.0	1.3	2.951	2.951	4.4
3.1	2.0	1.3	3.706	2.706	4.4
3.2	2.0	1.3	3.447	2.447	4.4

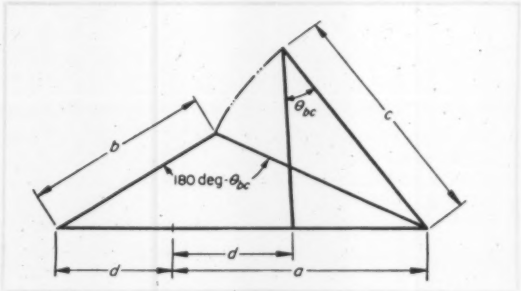


Fig. 4—Maximum and minimum included angles for links *b* and *c*

Tips and Techniques

Square Roots

Here are two slide rule methods which increase the accuracy of square root determinations.

Method 1: Find the square root of 883. Determine the square root by the conventional slide rule method, $(883)^{1/2} = 29.7$. Square 29.7 by long hand to obtain 882.09. Divide the difference between 883 and 882.09 by twice the value of the slide rule root. This operation is performed on the slide rule:

$$\frac{883 - 882.09}{2(29.7)} = 0.0153$$

Add the quotient 0.0153 to 29.7 to obtain the more accurate root, 29.7153. Exact root is 29.71531.—ROLF B. ERICSON, *Trollhattan, Sweden.*

Method 2: Find the square root of 97.65.

1. Set either index of the *B* scale opposite 97.65 on the *A* scale and read the trial solution 9.88 on the *D* scale opposite the *C* scale index.
2. Obtain a remainder by subtracting the square of the first digit in the trial solution from the number in question, $97.65 - 9^2 = 97.65 - 81 = 16.65$.
3. Obtain the divisor by replacing the first digit of the trial solution, 9, by twice its value, 18. The divisor then equals 18.88.
4. Divide the remainder, 16.65, by the divisor, 18.88, and obtain 0.882.
5. The more accurate square root is the first digit in the trial solution followed by the result of step 4, 9.882. The exact root is 9.8818.

—G. M. GILLESPIE, *assistant engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Simple types of cams for

ACTUATING LIMIT SWITCHES

By FRANK WILLIAM WOOD JR.
Design Engineer
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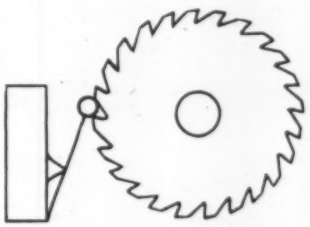
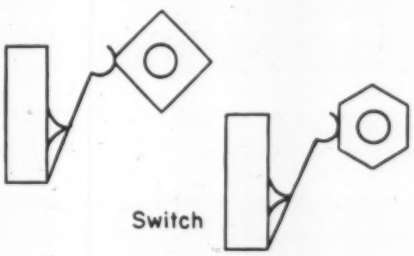
Silver Spring, Md.

For controlling sequence and duration of events in machines and processes, limit switches actuated by cams offer a host of design possibilities. Driven directly from a motor or through reduction gears, the cams can control on-off time intervals ranging from a fraction of a second to a week or more. Here's an assortment of simple cams to do this job.

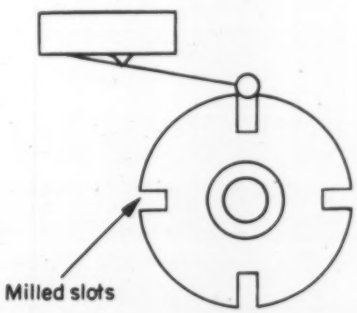
Ratchet shape provides many contacts per revolution. In this case, "on" and "off" time periods are equal.

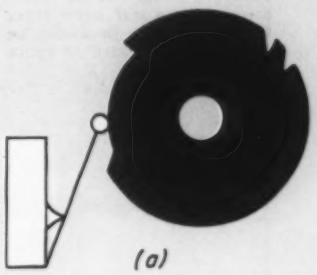


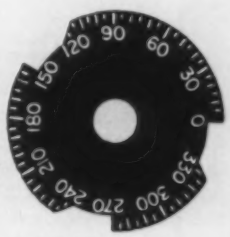
Geometric shapes are sections cut from commercial bar stock. Design considerations include accuracy of location of axial hole, and suitability of commercial tolerances on outside shape.



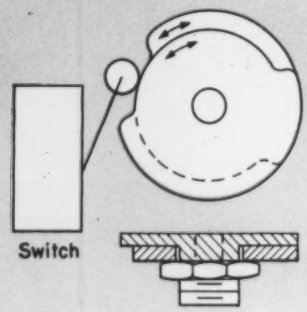
Slotted plate forms a fixed cam of unequal "on" and "off" periods. In small sizes, particularly, dimensions of slot relative to follower are critical. Follower must drop enough to trip the switch, but not jam in slots.

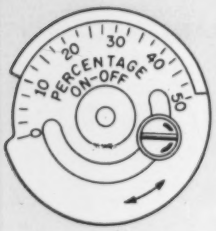




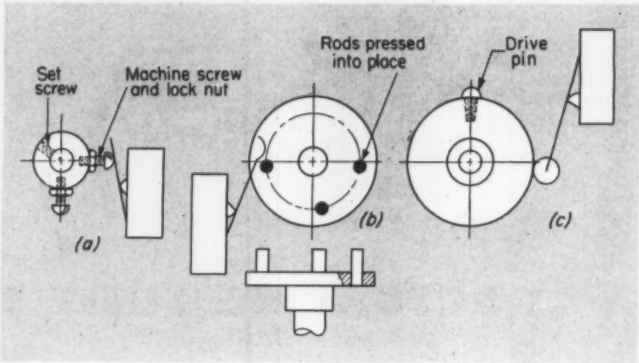


Irregular cycle is easy to set on the periphery of a flat plate. In example *a*, switch is on for 50 per cent of cycle, off 2 per cent, on 1 per cent, off 4 per cent, on 23 per cent, off 20 per cent. Graduations, *b*, indicate switching sequence and relative duration of intervals. Graduations may also be useful in forming the contour if wide tolerances are allowed.

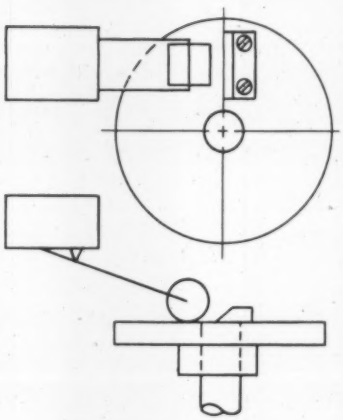




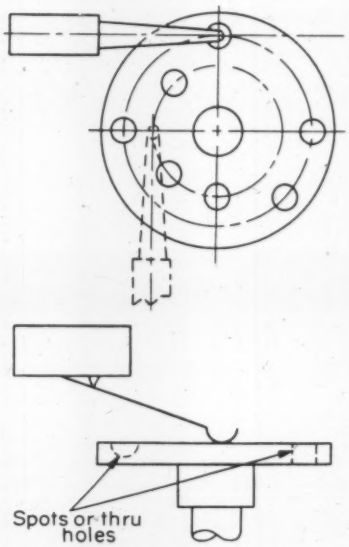
Readily adjustable, cam assemblies are formed of two plates that can be turned relative to each other, often without removal from machine. Various clamping means can be used—these are nut and screw types. Graduations may be useful, depending on accuracy of operation required.



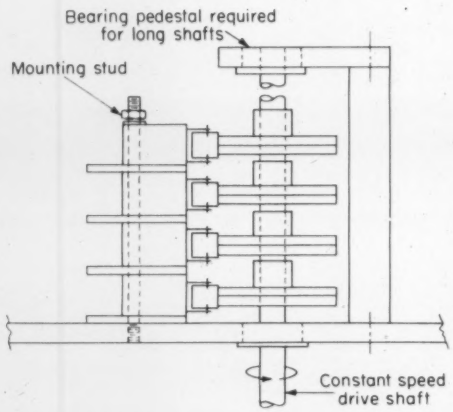
Standard hardware deflectors can be machine screws *a* locked in place, or rods *b* and headed pins *c* pressed into plates. Type *a* is readily adjustable, and type *b* has the advantage that rods can be pressed out from opposite cam face.



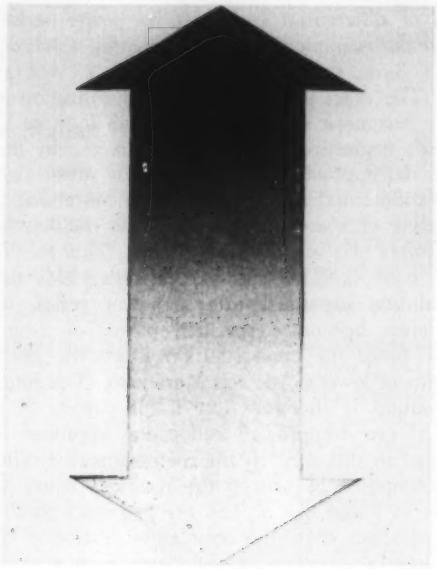
Riser plate deflects the follower once per revolution. Screws should not interfere with desired follower motion.



Alternate program is provided by a second pattern of holes concentric with the first. The second pattern could be "played" by translation of the original follower or by an additional follower.



Multiple cams on a single shaft control and synchronize a number of operations in a machine or process. Cams can be any plate type, but these are individually adjustable.



THERMAL STRESSES IN DESIGN

By S. S. MANSON
Chief, Material and Structures Research Div.
Lewis Research Laboratory, NASA
Cleveland, Ohio

Part 10— Elastic Stresses by Minimizing Residuals

• Collocations • Station Functions • Comparisons and Limitations

AMONG the methods for solution of thermal-stress problems, the station-function collocation method is the most general. Its particular merit lies in the treatment of two-dimensional problems, where the partial differential equations are replaced by a series of ordinary differential equations. At times, differential equations are not involved at all. Because of the generality of the method, and because its use has thus far been limited, the component features are described in some detail through the use of a highly simplified example.

▶ Collocations

The collocation approach involves assuming the solution of a differential equation to be in a specified form involving several constants, and then determining the constants so that the assumed solution satisfies the differential equation at a limited number of values of the independent variable.

Assume a simple differential equation $y-(dy/dx) = 0$, such that $y = 1$ at $x = 0$. If the exact solution $y = e^x$ is substituted into the left hand side of this equation, the result will be zero for all values of x. However, if an approximate solution for this equation, $y = 1 + bx + cx^2$, is substituted into the left-hand side of the equation, (see Nomenclature)

$$y - \frac{dy}{dx} \equiv (1 + bx + cx^2) - (b + 2cx) \qquad (54)$$

Obviously the expression is not equal to zero for all values of x. The difference between the value of this expression and zero is called the residual. Its value depends not only on x, but on the choice of the constants b and c. These constants are determined by specifying conditions that lead to two simultaneous equations for b and c.

For example, the residuals of values for x_1 and x_2 could be selected as zero. This provides two

equations for determining b and c. If, in Equation 54, the residuals are set equal to zero at $x_1 = 0$ and $x_2 = 1$, then $b = c = 1$, and $y = 1 + x + x^2$ is the indicated solution for the differential equation from $x = 0$ to $x = 1$. The validity of approximation can be proved by comparing the approximate solution to the exact solution at several values of x.

At $x = 0$, $\frac{1}{2}$, and 1 the approximate solutions are 1.0, 1.75, and 3.0 while the exact solutions are 1.0, 1.649 and 2.718, respectively. Obviously the degree of approximation can be improved if more disposable constants are introduced. For example assuming the solution in the form $y = 1 + bx + cx^2 = dx^3$ leads to

$$y - \frac{dy}{dx} \equiv (1 + bx + cx^2 + dx^3) - (b + 2cx + 3dx^2) \qquad (55)$$

This permits the residuals to be set equal to zero at more than two stations.

Two factors should be pointed out regarding the collocation method. First, although the residuals were set equal to zero at selected stations, it cannot be assumed that the value of the dependent variable y for the approximate and exact solutions will be equal at the selected stations. In general, however, if the differential equation is satisfied at a reasonable number of points, the solutions will be in reasonable agreement.

Second, there is a considerable difference between an approximate power-series solution determined by collocation approach and the power series determined by the conventional procedure used in the solution of differential equations by power series. An extreme example is the differential equation $dy/dx = 3y/x$, subject to the condition $y = 1$ at $x = 1$. The exact solution by direct substitution is $y = x^3$. Assume a solution in the form $y = a + \omega x + cx^2$, neglecting all terms beyond x^2. In the conventional approach, this expression is substituted into the differential equation, all terms containing a given power of x are collected, and the coefficients of all powers of x are equated to zero. This results in $a = b = 0$. This approach always yields the exact solution expanded into a power series, in which terms beyond a specified power of x are dropped. Since the exact solution is x^3, the exact coefficients of lower power terms are zero. The complete solution is therefore lost if all powers of x beyond x^2 are dropped. A collocation approach is not limited in this way. If the coefficients a, b, and c are determined by setting the residuals equal to zero at $x = 1$ and $x = 2$, and the boundary condition is satisfied, then the approximate solution of the differential equation in the range from $x = 1$ to $x = 2$ is $y = 4 - 9x + 6x^2$. This solution bears little resemblance to the exact solution, but numerically the two expressions are in close agreement in this range of x. Certainly the agreement is better than with the restricted power series approach which led to $y = 0$ everywhere.

Conversion to Integral Equations: One introduction of error in a collocation solution occurs when the derivatives are taken. Even though the curve for a given function is approximated with reasonable accuracy by another curve, the derivatives of the two curves may differ appreciably. The accuracy of a solution may therefore be increased if the differential equation is converted to an integral equation, in which slopes of curves are replaced by areas under curves.

For example, Equation 54 is converted to an integral equation by multiplying both sides by dx and integrating between the origin and any point x, y, along the curve. Since $x = 1$ at $y = 0$,

$$\int_0^y dy = \int_0^x y\,dx \text{ or } y - 1 = \int_0^x y\,dx \qquad (56)$$

If the solution is in the form $y = 1 + ax + bx^2$, Equation 56 becomes

$$ax + bx^2 = x + \frac{1}{2}ax^2 + \frac{1}{3}bx^3 \qquad (57)$$

Satisfying the equation at $x = \frac{1}{2}$ and $x = 1$ provides two relations for a and b, from which $a = b = 6/7$, and the approximate solution becomes

$$y = 1 + \frac{6}{7}x + \frac{6}{7}x^2 \qquad (58)$$

This solution gives y values of 1.0, 1.643 and 2.715 at $x = 0$, $\frac{1}{2}$, and 1, respectively. These compare to exact values of 1.0, 1.648, and 2.718.

Unfortunately it is not always convenient to transform the differential equation into an integral equation. Therefore, in the applications described

Nomenclature

A	Cross-sectional area
a, b, c, d	Arbitrary constants
E	Elastic modulus
h	Thickness
I	Moment of inertia
L	Length
n	Distance normal to boundary surface
p, q, r, s	Boundary points
r	Radius or radial
S	Surface
T	Temperature
t	Tangential
u, v, w	Displacements
V	Volume
X, Y, Z	Body forces
X_s, Y_s, Z_s	Surface forces
α	Coefficient of expansion
δ	Deflection
ϵ	Strain
μ	Poisson's ratio
ρ	Density of material
σ	Stress
ϕ	Stress function
ω	Rotation
del^2	Laplacian operator
del^4	Operator
$\int_p$	Line integral

here the collocation procedure is applied directly to the differential equation, although in some cases, greater accuracy could be achieved by conversion to integral equations.

Station Functions

In some applications such as in the solution of two-dimensional problems, it is desirable to express the general solution in terms of solutions at selected stations. For example, the solution of the differential equation $y = dy/dx$ can be expressed in the form

$$y = P_0(x)y_0 + P_{1/2}(x)y_{1/2} + P_1(x)y_1 \qquad (59)$$

where y_0, $y_{1/2}$ and y_1 are the unknown solutions for y at $x = 0$, $1/2$, and 1, and $P_0(x)$, $P_{1/2}(x)$ and $P_1(x)$ are station functions.[10] The form of the station functions is determined by inspection. For y to equal $y_{1/2}$ at $x = 1/2$, $P_0(1/2)$ and $P_1(1/2)$ must be zero. Thus $P_0(x)$ and $P_1(x)$ must contain the factor $x - (1/2)$. Similarly $P_{1/2}(x)$ and $P_1(x)$ contain the factor x while $P_0(x)$ and $P_{1/2}(x)$ contain the factor $(x - 1)$. To make $P_0(x)$, $P_{1/2}(x)$ and $P_1(x)$ unity at $x = 0$, $1/2$, and 1, respectively, the station functions must be divided by the proper normalizing constants. Thus,

$$y = \frac{(x - 1/2)(x - 1)}{(0 - 1/2)(0 - 1)} y_0 + \frac{(x - 0)(x - 1)}{(1/2 - 0)(1/2 - 1)} y_{1/2} + \frac{(x - 0)(x - 1/2)}{(1 - 0)(1 - 1/2)} y_1 \qquad (60)$$

This equation takes on the values y_1, $y_{1/2}$, and y_1 at $x = 0$, $1/2$, and 1. Boundary conditions are usually placed on values of functions and their derivatives at specified locations and it is this property that makes the station-function concept useful.

If Equation 60 is employed in a collocation solution in either the differential equation or the integral equation, Equation 56, the values of $y_{1/2}$ and y_1 can be found. The station-function approach is particularly advantageous when used to convert partial differential equations into ordinary differential equations for easier solution. This approach was developed in connection with thermal-shock problems, where the principal detail was the determination of temperature distribution.[11] It has also been applied to the solution of the biharmonic equation.[12]

Application to Partial Differential Equations: If a plate 2 by $6K$ is subjected to transverse temperature distribution $T = T_0(y^2 - 1/3)$, the determination of the thermal stresses requires the solution of the biharmonic equation $\mathrm{del}^4\phi + E\alpha\mathrm{del}^2T = 0$.[8] For this solution, values of the stress function ϕ must be obtained. In accordance with the collocation and station-function concepts, values of ϕ at the ordinates $y = 1/4$ and $3/4$ must be determined. These quantities are functions of x, along the lines AA and BB, Fig. 65.

Assume that $\phi_{1/4}$ and $\phi_{3/4}$ have been established at $x = x_1$. It is necessary then to estimate the variation of ϕ across the plane CC. This is accomplished by passing a polynomial through the values $\phi_{1/4}$ and $\phi_{3/4}$. The polynomial is consistent with boundary conditions, ϕ and $\partial\phi/\partial y$ equal to zero for this particular section. Because of the symmetry of the temperature, $\phi(y) = \phi(-y)$, and the polynomial contains only even powers of y. Assume the equation for ϕ across the section:

$$\phi = P_{1/4}(y)\phi_{1/4}(x) + P_{3/4}(y)\phi_{3/4}(x) \qquad (61)$$

Functions $P_{1/4}(y)$ and $P_{3/4}(y)$ are written by inspection. Term $P_{1/4}(y) = 0$ at $y = \pm 3/4$, and contains the factor $(y^2 - \frac{9}{16})$. From boundary con-

[10]References are tabulated at end of article.

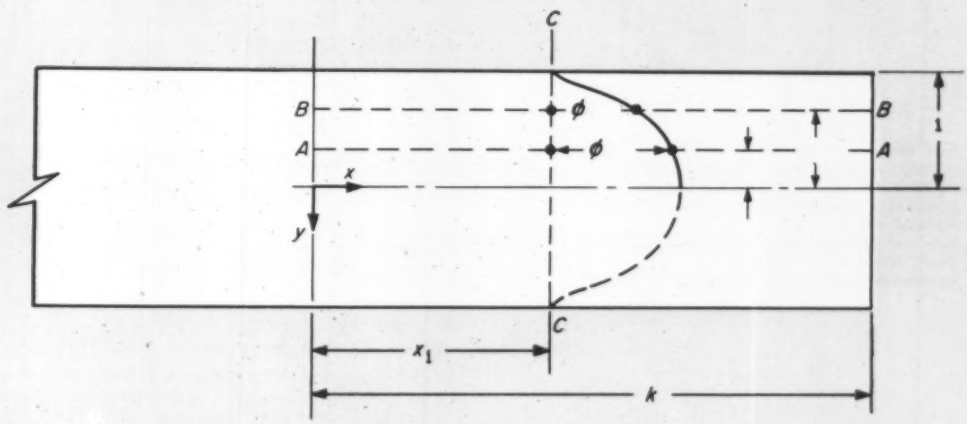


Fig. 65—Passing a polynomial approximation through $\phi_{1/4}$ and $\phi_{3/4}$. Lines BB and AA are located at y values of $3/4$ and $1/4$

ditions, $P_{1/4}$ and its derivative equal zero at $y = \pm 1$. Hence, it contains the factor $(y^2 - 1)^2$. Finally, the polynomial contains a normalizing denominator which causes the polynomial to become unity at $y = 1/4$. Thus,

$$P_{1/4} = \frac{(y^2 - 1)^2(y^2 - 9/16)}{(1/16 - 1)^2(1/16 - 9/16)}$$

$$= -\frac{512}{225}(y^2 - 1)^2(y^2 - 9/16) \qquad (62)$$

Similarly,

$$P_{3/4} = \frac{(y^2 - 1)^2(y^2 - 1/16)}{(9/16 - 1)^2(9/16 - 1/16)}$$

$$= \frac{512}{49}(y^2 - 1)^2(y^2 - 1/16) \qquad (63)$$

Since the numerical values of the even derivatives of P_1 and P_2 enter into later equations, and since these values depend only on the choice of stations, not temperature distribution, they can be tabulated:

$P_{1/4}(1/4) = 1$	$P_{1/4}''(3/4) = 0$
$P_{1/4}''(1/4) = -5.564$	$P_{1/4}''(3/4) = -8.089$
$P_1''''(1/4) = 88.75$	$P_{1/4}''''(3/4) = -320.8$
$P_{3/4}(1/4) = 0$	$P_{3/4}(3/4) = 1$
$P_{3/4}''(1/4) = 8.571$	$P_{3/4}''(3/4) = -22.78$
$P_{3/4}''''(1/4) = -282.1$	$P_{3/4}''''(3/4) = 1599$

With ϕ expressed in terms of Equation 61, where the P terms are known functions of y and the $\phi_{1/4}(x)$ and $\phi_{3/4}(x)$ terms are unknown functions of x, it is possible to substitute into the biharmonic equation:

$$\frac{\partial^4\phi}{\partial x^4} + 2\frac{\partial^4\phi}{\partial x^2 \partial y^2} + \frac{\partial^4\phi}{\partial y^4} = P_{1/4}\phi_{1/4}'''' + P_{3/4}\phi_{3/4}'''' +$$

$$2(P_{1/4}''\phi_{1/4}'' + P_{3/4}''\phi_{3/4}'' + P_{3/4}''''\phi_{3/4}$$

$$= -\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right)[E\alpha T_0(y^2 - 1/3)] = -2E\alpha T_0 \qquad \ldots.(64)$$

where $P_{1/4}$ designates $P_{1/4}(y)$, and similarly for the other P and ϕ values.

Equation 64 can be collocated at $y = 1/4$ and $3/4$ to give two differential equations:

$$\phi_{1/4}'''' - 11.13\phi_{1/4}'' + 88.75\phi_{1/4} + 17.14\phi_{3/4}'' - 282.1\phi_{3/4}$$

$$= -2E\alpha T_0$$

$$16.18\phi_{1/4}'' - 320.8\phi_{1/4} + \phi_{3/4}'''' - 45.55\phi_{3/4}'' + 1599\phi_{3/4}$$

$$= -2E\alpha T_0 \qquad (65)$$

where the values for P are obtained from the previous tabulation.

In this problem, the right-hand side of Equations 65, which relates to the term del^2T, is independent of both x and y. In the more general case, del^2T depends on both x and y. The y term is removed in Equations 65 by specific substitution. Hence, the right-hand side of Equations 65 contains functions of x only, and the x functions $\phi_{1/4}$ and $\phi_{3/4}$ can be determined.

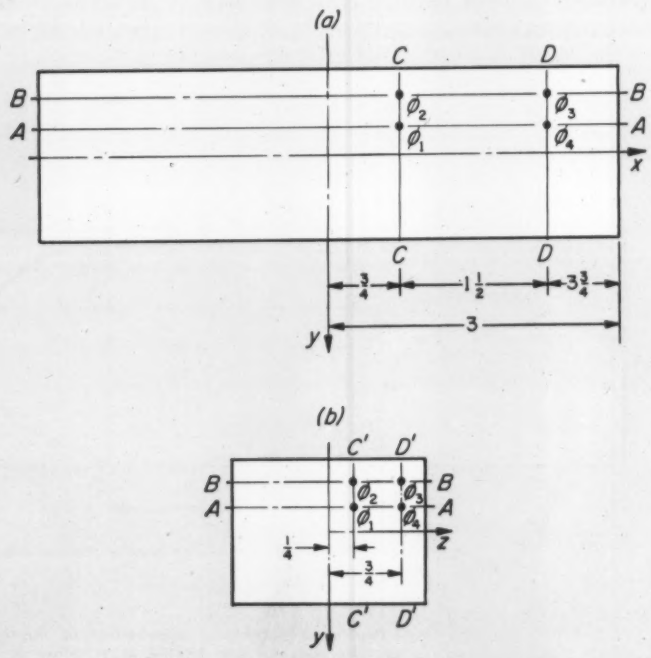


Fig. 66 — Application of double collocations to solution of partial differential equation for thermal stress. Conversion of, *a*, rectangular plate into, *b*, square plate by transformation $z = 3x$

Solution by Classical Means: Since Equations 65 represent a set of ordinary differential equations with constant coefficients, their solution can be approached by classical means. The first step is to determine a particular solution. Since the right-hand side of the equations are constants, the particular solutions $\phi_{1/4,\,p}$ and $\phi_{3/4,\,p}$ are taken as constant and Equations 65 give

$$\phi_{1/4,p} = -0.07324\,E\alpha T_0 \quad \phi_{3/4,p} = -0.01595\,E\alpha T_0 \qquad (66)$$

In more general cases of temperature distribution, the right-hand side of Equations 65 is in functions of x. For simple functions such as polynomials and exponentials, the particular integrals can be determined by assuming them to be of the same form, but with several undetermined coefficients which are then evaluated by substitution into Equations 65. In cases where a particular integral cannot be found easily, the classical approach should not be used.

The second step is to determine the complementary solution, which is the solution of Equations 65 with the right-hand side set equal to zero. Assume $\phi_{1/4} = A_k e^{\lambda(k)x}$ and $\phi_{3/4} = B_k e^{\lambda(k)x}$. Substitution of these values into Equations 65 results in a determinental equation for λ_k and the relation between B_k and A_k:

$$B_k = -\frac{\lambda_k^4 - 11.13\lambda_k^2 + 88.75}{17.14\lambda_k^2 - 282.1} A_k \qquad (67)$$

The determinental equation has eight roots, $\lambda_{1,2,3,4} = \pm (2.120 \pm 1.117\,i)$ and $\lambda_{5,6,7,8} = \pm (5.682 \pm 2.681\,i)$. The complete solution is the sum of the particular integral and all the homogeneous solutions.

$$\phi_{1/4} = -0.07324 E\alpha T_0 + \sum_{k=1}^{8} A_k l^{\lambda(k)x}$$

$$\phi_{3/4} = -0.01595 E\alpha T_0 + \sum_{k=1}^{8} B_k l^{\lambda(k)x} \qquad (68)$$

Since B_k is related to A_k, Equation 68 represents the solution for $\phi_{1/4}$ and $\phi_{3/4}$ in terms of eight unknowns, which are determined from the eight boundary conditions.

Solution by Double Collocations: Although straightforward, solution of the differential Equation 65 by classical means becomes cumbersome. Not only does the final solution contain many terms, but solutions and manipulations of complex numbers are involved. Furthermore, determination of a particular integral is difficult unless the temperature is specified in simple functions. These difficulties are avoided by using a double-collocation method, in which the collocation procedure is used for solution as well as formulation of these equations. Continuous variation of ϕ along the lines *AA* and *BB* is defined by Equation 65.

Instead of solving for $\phi_{1/4}$ and $\phi_{3/4}$ to exactly satisfy Equations 65, an approximate solution is found in which these equations are satisfied only at ordinates corresponding to *CC* and *DD*. First, a station-function polynomial is written for ϕ at each point along line *AA* and *BB*. Since station functions are already formulated in Equations 62 and 63 and the various derivatives have been tabulated, they can be used by transforming x into a variable z, so that the abscissas along *CC* and *DD* become $1/4$ and $3/4$ instead of $1/4 \times 3$ and $3/4 \times 3$, Fig. 66*b*. This transformation is $z = 3x$, and $d^2\phi/dx^2 = (1/9)(d^2\phi/dz^2)$ and $d^4\phi/dx^4 = (1/81)(d^4\phi/dz^4)$. Substitution of these terms into Equation 65 gives

$$0.01235\,\phi_{1/4}'''' - 1.237\,\phi_{1/4}'' + 88.75\,\phi_{1/4} + 1.905\,\phi_{3/4}'' - 282.1\,\phi_{3/4} = -2E\alpha T_0 \qquad (69)$$

and

$$1.798\,\phi_{1/4}'' - 320.9\,\phi_{1/4} + 0.01235\,\phi_{3/4}'''' - 5.061\,\phi_{3/4}'' + 1598.7\,\phi_{3/4} = -2E\alpha T_0 \qquad (70)$$

where the differentiations refer to the variable z. If ϕ_1 and ϕ_4 are the numerical values of ϕ along *AA*, and ϕ_2 and ϕ_3 the values along the line *BB*, the value of ϕ, at any other point along the line *AA*, is

$$\phi_{1/4} = -\frac{512}{225}(z^2-1)^2(z^2-\tfrac{9}{16})\phi_1 + \frac{512}{49}(z^2-1)^2(z^2-\tfrac{1}{16})\phi_4 \qquad (71)$$

and along the line *BB*, the value of ϕ is

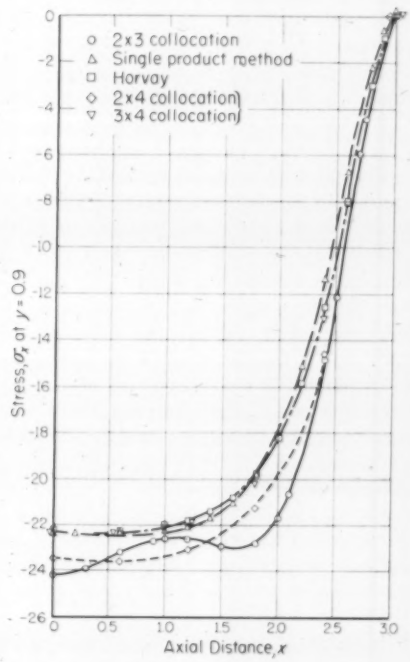


Fig. 67—Axial stress distribution in a plate of dimensions 2 by 6 units with constant temperature in axial direction and transverse temperature $T = T_0\,(1 - y)^9$ $E\alpha T_0 = 130{,}600$

$$\phi_{3/4} = -\frac{512}{225}(z^2 - 1)^2(z^2 - \tfrac{9}{16})\phi_2 + \frac{512}{49}(z^2 - 1)^2(z^2 - \tfrac{1}{16})\phi_3 \quad (72)$$

If Equations 71 and 72 are substituted into Equations 69 and 70, four simultaneous algebraic equations in the quantities ϕ_1, ϕ_2, ϕ_3, and ϕ_4 result. These equations can then be solved for numerical values of the quantities. Once ϕ_1, ϕ_2, ϕ_3, and ϕ_4 are known, they are substituted into Equations 71 and 72, and z is replaced by $3x$, which yields $\phi_{1/4}$ and $\phi_{3/4}$ as functions of x. Substitution of $\phi_{1/4}$ and $\phi_{3/4}$ into Equation 61 yields the complete variation of ϕ with x and y. The stresses are then determined from Equation 37.

Results obtained by this method can be made more accurate by collocating at a larger number of stations.[12] However, the number of stations should be kept as small as is consistent with the needs of the particular problem.

Solution by Finite Differences: Although the double-collocation technique for linear differential equation solution proves completely satisfactory in most cases, it is often desirable to make sure that the nodal stations have not omitted regions of large variable changes. A check approach is obtained if the set of linear equations which result from the first collocation are solved by the method of finite differences. The procedure is similar to that discussed in connection with the rotating disc.[9] In this case, however, the equations are of higher order. This problem is overcome by expressing the higher-order derivatives at a point in terms of the values at several adjacent stations. Alternatively, the higher-order derivatives are designated as new variables, and additional equations formed by the interrelation of the various variable derivatives.

Application to Energy Methods: The application of station-function collocations in conjunction with the energy approach has already been indicated.[8] The procedure is similar to the application to biharmonic equations and no further details are needed. Construction of the station functions in y is identical, but the set of simultaneous ordinary differential equations for the x functions result from application of the variational equations[8] instead of the biharmonic equation, Equation 27.[6] Because both methods are approximations, the ordinary differential equations which result are not identical for identical problems.

Application to Plates of Variable Thickness: In all the illustrative descriptions presented, application has been to a flat plate because the principal objective has been to illustrate methods. When the plate thickness varies, the problem lends itself to the same basic methods. However, the governing partial differential equation, instead of being the simple biharmonic equation, contains several additional terms that arise from the thickness variation.[12]

Comparisons and Limitations

Results of some computations made by the station-function collocation procedure, which used single and double collocations and several station numbers, are shown in Fig. 67. It can be seen that a large number of stations is not needed, and that the double-collocation procedure yields results nearly identical to that of the single-collocation method.

However, caution should be used when double collocations are applied. The problem treated was that of a plate with dimensions of 2 by 6 units. The axial stress was maximum at the center, and dropped gradually to zero at the end of the plate. Thus, knowledge of the value of the stress, of stress-function, at several points along the curve, together with some boundary conditions, served as an adequate guide for establishment of the complete curve.

If, however, the problem were one of a very wide plate under the same temperature conditions, the stress along most of the length of the beam would be constant. Only near the end would it suddenly drop to zero. Thus, prediction of the stress distribution near the end of the plate from knowledge of the stress in the region where it is uniform does not yield good results. Of course the boundary condition forces the stress to zero at the end, but the precise variation of stress near the end could not be expected to be good. Thus, it is necessary to use a large number of stations in the x direction. Alternately, since stress distribution near the end is not much different from an infinitely wide beam, a parallel problem which yields well to a double-collocation procedure could be set up.

The single-collocation procedure could be applied in this case, since solution for x values gives a function which changes little over a long distance, and drops abruptly. It could be susceptible to this disadvantage, however, if the temperature has abrupt changes in the y direction in regions removed from the stations chosen for collocation. In such cases, solution by the single-collocation procedure with finite differences have been used effectively to solve the resulting system.

Elastic Stresses—In Summary

Many methods of solution of plane elastic problems have been described. Each has a field of application, and none is free from limitations. When the body is long in one dimension compared to others, then the beam-analysis approach leads most simply to the determination of the most significant stresses. Only near the ends is refinement necessary.

Classical methods of building up solutions from particular solutions of the biharmonic equation, fitting the boundary conditions by adjusting coeffi-

cients, leads to cumbersome and inaccurate results. Here, approximation of the solution by functions that everywhere satisfy the boundary conditions, but only approximately satisfy the biharmonic equations, are of value. Various energy methods use this approach. Of these, the single-product method is of limited use, because of the assumption that the final solution for the stress function can be expressed in terms of a single product in x and y. Self-equilibrating polynomials are useful in some cases, while the energy method which uses station functions and collocations provides considerable generality.

The direct method of applying station functions and collocation to the solution of the ordinary and partial-differential equations is the most general and directly applicable. Finite differences are also useful in the solution of ordinary differential equations which arise either directly from the equilibrium and compatibility equations in one-dimensional problems, or indirectly from collocations used in two-dimensional problems. When the geometric boundaries of a body are irregular, finite differences, in conjunction with relaxation techniques, are useful.

Since most problems of practical interest involve approximate solutions, the availability of several methods which can act as a check on each other is fortunate. It is also possible to use the methods in conjunction with each other.

The next article in this series will discuss thermal-stress distribution in the plastic range.

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This article is the tenth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" ... June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" . August 7, 1958
4. "Causes of Fatigue in Ductile Materials" ..... August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" ..... January 22, 1959
7. "Exact and Approximate Solutions" ..... February 5, 1959
8. "Elastic Stresses by Energy Methods" ..... February 19, 1959
9. "Elastic Stress Solutions" ..... March 5, 1959

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10. Manfred Rauscher—"Station Functions and Air Density Variations in Flutter Analysis, *Journal Aero Science*, Vol. 16, No. 6, June 1949, pp. 345-354.
11. A. Mendelson and S. S. Manson—"Approximate Solution to Thermal Shock Problems in Plates, Hollow Spheres, and Cylinders with Heat Transfer at Two Surfaces," *ASME Transaction*, Vol. 78, No. 3, April, 1956, pp. 545-553.
12. A. Mendelson and M. Hirschbert—"Analysis of Elastic Thermal Stresses in Their Plate with Spanwise and Chordwise Variations of Temperature and Thickness," *NACA Technical Note 3778*, 1956.

Thermal Stresses in Design—Part 7

In "Thermal Stresses in Design," Pages 114-121, February 5 issue, the second paragraph in the second column on Page 117 should be deleted and the following equations inserted:

$$D_m = \frac{-4(-1)^m \sinh m\pi\left(\frac{a}{b}\right)}{\left[m\pi\left(\frac{a}{b}\right) + \frac{1}{2}\sinh 2\pi m\left(\frac{a}{b}\right)\right]} \times \frac{1}{\pi m^4\left(\frac{b}{a}\right)^3} \sum_{n=1}^{\infty} \frac{(-1)^n n^3 \sinh n\pi\left(\frac{b}{a}\right)}{\left[1 + \left(\frac{nb}{ma}\right)^2\right]^2} B_n$$

$$B_n = \frac{-4(-1)^n \sinh n\pi\left(\frac{b}{a}\right)}{\left[n\pi\left(\frac{b}{a}\right) + \frac{1}{2}\sinh 2\pi n\left(\frac{a}{b}\right)\right]} \times \frac{1}{\pi n^4\left(\frac{b}{a}\right)^3} \sum_{m=1}^{\infty} \frac{(-1)^m m^3 \sinh m\pi\left(\frac{a}{b}\right)}{\left[1 + \left(\frac{nb}{ma}\right)^2\right]^2} D_m + \frac{\sinh \pi n\left(\frac{b}{a}\right) \int_{-1}^{+1} \phi_p(z) \cos \pi n z\, dz}{\pi n\left(\frac{b}{a}\right) + \frac{1}{2}\sinh 2\pi n\left(\frac{b}{a}\right)}$$

where, in this case, $z = y/a$ and $\phi_p = -(y^4 - 2y^2 + 1)/12$.

They Say . . .

"Until recent years too much of engineering training was devoted to 'practice' and too little to mathematics and science. Drafting, shop work, power or chemical plant or structure design are typical of the 'practice' courses. However, in recent years the amount of 'practice' in the curricula has decreased and the amount of science and mathematics increased. This trend, which in many of our engineering schools has a long way to go, should continue. Also the number of engineers continuing in academic institutions beyond the four years is slowly increasing. The trend should be accelerated, but residence should be in schools with faculties and facilities adequate for graduate instruction. The professional engineering societies and industry can make large contributions to curricula improvement and increased graduate training."—MELVIN J. KELLEY, *board chairman, Bell Telephone Laboratories.*

"The conduct of applied research has been compared to the performance of a symphony orchestra. At times the score calls for a single instrument to perform in solo, but generally a greater variety of instruments is required for richer, fuller results. With the complex score of today's problems, the technique of a single science may be effective on some occasions, while on others several acting in concert produce the most favorable results."—E. FINLEY CARTER, *director, Stanford Research Institute.*

The Personal Side of Engineering

By **EDWIN C. NEVIS** Personnel Research and Development Corp., Cleveland, Ohio

Measuring Job Performance

MANY companies have programs for evaluating performance of engineers on a systematic basis. Several engineering unions advocate some kind of merit rating to determine the value and, thus, the compensation or promotion of engineers.

Typically, as a carryover from earlier days of merit rating, performance-evaluation systems are based largely on an appraisal of the individual's past performance. They are designed primarily for administrative use in making salary, placement, or promotion decisions. Their main objective is to arrive at some rating or ranking of an individual on the basis of his performance.

These programs often center on a manager's evaluation of his subordinates, without consideration of the subordinates' views and attitudes. So the program is often challenged as not presenting a fair picture.

Many such programs emphasize an evaluation of the individual's personality. For instance, they include ratings on such traits as conscientiousness, loyalty, co-operativeness—characteristics which are difficult to define, let alone measure. And, although they may perhaps single out poor performance, they do little to bring about improvement.

A more recent approach, which is gaining a great deal of acceptance, is the *performance-planning review*, as distinguished from the performance evaluation. Here, the major emphasis is on working with an employee. The review has two aims: 1. Help the employee understand the objectives and goals of his job better. 2. Assist him to develop himself to improve his performance in meeting these goals or objectives.

In a typical performance-review program, the individual and his superior meet periodically. They establish goals or objectives for the individual to work toward over future months. The emphasis is on future planning, rather than on hashing over past performance.

One big advantage of this approach is that the employee helps establish his own work goals and objectives. Communication breakdowns are usually avoided, for both the individual and his superior agree on what is expected as satisfactory performance. Later on, when the individual's performance is reviewed against these standards, both the individual and his superior operate within the same frame of reference.

The technique is of great value in developing management personnel, for it requires the employee to set goals and also to plan specific programs to achieve these goals. This provides a basis for acquiring experience in the active, direct responsibility of operating a job or department.

Though performance-review programs are rare among engineering departments at the moment, they can play a great part in improving communication and understanding among engineers and their managers. Too many engineering managers are disturbed about the work of subordinates, without having arrived in their own minds at a clear-cut definition of acceptable performance.

The engineer, on the other hand, lacks a clear definition of adequate performance. So he fills in one of his own. Unless he and his superior can review this definition and come to some common understanding, resentment will be created on both sides if "adequate" performance is not achieved.

While such programs require skill and sensitivity from engineering managers, the technique for conducting them can be mastered more readily than for merit-rating procedures. For here, the task is to review together specific aspects of the job, not to judge the individual's performance or personality. Since the planning review is a joint process, difficulties experienced by superiors in criticizing and evaluating subordinates can be minimized. The approach encourages the employee to appraise himself and to determine his own needs for development and improvement.

THIN-WALLED CIRCULAR BEAMS

. . . how to design them to prevent collapse due to bending loads

By H. D. TABAKMAN
Consultant
North Highlands, Calif.

REDUCTION in weight of structural members is often achieved by using members with thin-walled cross sections. As a consequence, conventional concepts and methods which involve normal elastic analysis must be complemented with an analysis of the elastic stability of the structural member.

Equations and charts are presented here to aid in the design of hollow structural members which will not collapse under flexure.

Analysis: Simple bending theory states that a cross section of a beam in bending becomes more efficient as the material is placed farther from the neutral axis. From this statement, two conclusions are drawn: A hollow cross section is more economical in material than a solid cross section, and the wall thicknesss can be reduced if the distance from the neutral axis is increased. However, the latter conclusion is not true in practice, since elastic instability occurs before the cross section can develop its maximum strength. Hence, to select a hollow cross section, which is economic in weight and material, the deformation, stresses, and criteria that govern collapse must be determined.

As a basis for rational design, the physical significance of flexural instability is: Displacement within the plane of cross section of any point in the cross section constitutes a condition of instability. Hence, deformation of the cross section is formed by the displacement of its constituent points. Moreover, the distinctions between the two stages of deformation are: 1. If the external bending moment which produces the displacements is removed and the displacements vanish, a state of initial instability

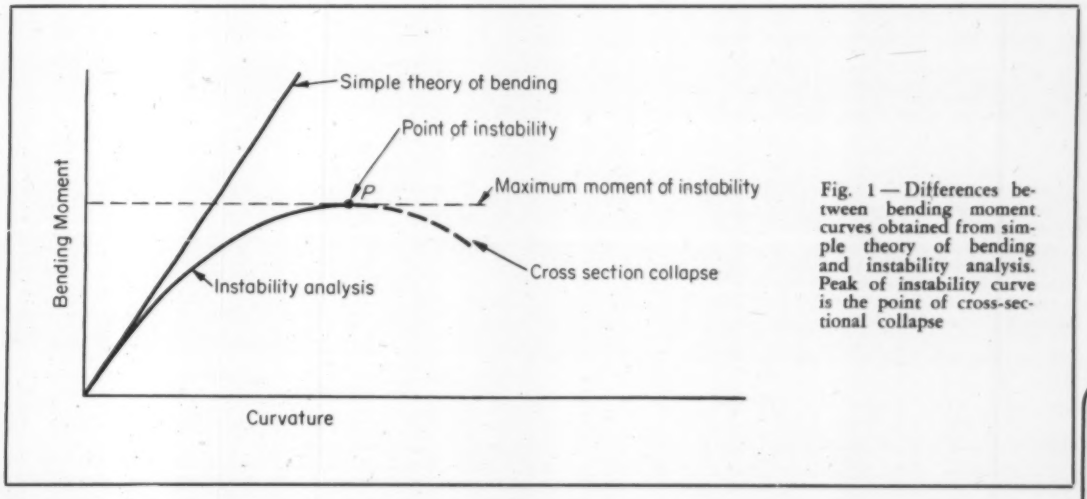


Fig. 1 — Differences between bending moment curves obtained from simple theory of bending and instability analysis. Peak of instability curve is the point of cross-sectional collapse

exists. 2. A condition of permanent instability exists if a slight increase in external bending collapses the cross section geometrically.

The range of initial instability described in stage 1 is shown graphically in Fig. 1, and extends along the curve from point O to point P. Point P represents stage 2.

To determine the shape of the cross section at initial instability, the effect of the bending-stress distribution on a circular thin-walled cross section of an annular ring, Fig. 2, is considered. If an element is cut out of the ring by two adjacent radial planes at an angle $d\theta$ apart, bending stresses have radial components acting in an inward direction because of the curvature of the element. These components tend to flatten the cross section into an oval shape, Fig. 3. Thus, a point originally at m moves to m_1, and the strain of the median line of the cross section is made up of two components. One component is due to the tangential displacement, dv/ds, and the other to the radial displacement, $-w/R$.

Nomenclature

- a = Maximum radial deflection in cross section at $\theta = 0$, in.
- E = Young's modulus of elasticity, psi
- I_a = Actual moment of inertia of cross section, in.^{4}
- I_o = Moment of inertia of cross section in undeformed state, in.^{4}
- M = External bending moment, lb-in.
- M_t = Transverse bending moment, lb-in.
- R = Radius of cross section, in.
- r = Radius of ring, in.
- t = Wall thickness, in.
- v = Tangential displacement in plane of cross section, in.
- w = Radial displacement in plane of cross section, in.
- Z_o = Modulus of section in its undeformed state, in.^{3}
- θ = Angle between planes, deg
- ν = Poisson's ratio
- ρ = Curvature of ring in plane with cross section in deformed state, in.$^{-1}$
- σ_a = Maximum actual bending stress, psi
- σ_n = Maximum nominal bending stress, psi
- σ_t = Maximum bending stress due to transverse bending moment, psi

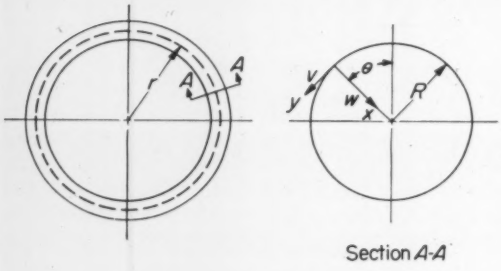


Fig. 2—Annular ring with thin-walled circular cross section. Section A-A is enlarged

Equations: Analysis of the bending moment, which produces instability, and of the displacement equations for w and v is based on three factors: The principle of minimum potential energy, the assumption of an inextensible middle surface in the cross section, and the complementary theorem. The displacement equation for v is (see Nomenclature)

$$v = \frac{a}{2} \sin 2\theta \qquad (1)$$

and the equation for w is

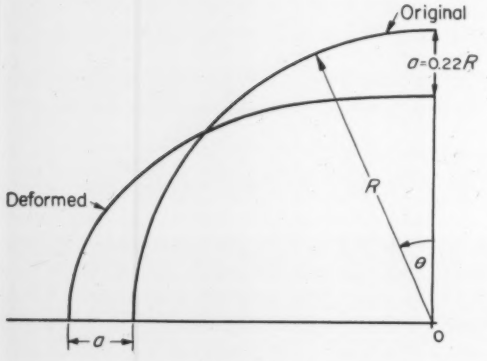
$$w = a \cos 2\theta \qquad (2)$$

where $a = (1 - \nu^2)\rho^2 R^5/t^2$.

The assumption of inextensibility yields a direct relationship between the radial and tangential displacements. Thus, the energy equation can be expressed in terms of one displacement component. Substitution for v in the energy equation and subsequent application of the complementary theorem yields the external bending moment which produces instability:

$$M = \frac{\pi}{2} E R^3 t \left[2\rho - 3(1 - \nu^2) \frac{R^4}{t^2} \rho^3 \right] \qquad (3)$$

The expression for a, is solved for ρ, and is substituted in Equation 3:



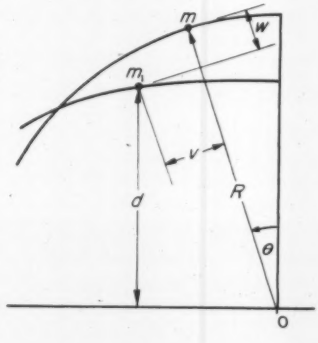


Fig. 3 — Deformation of cross section under load

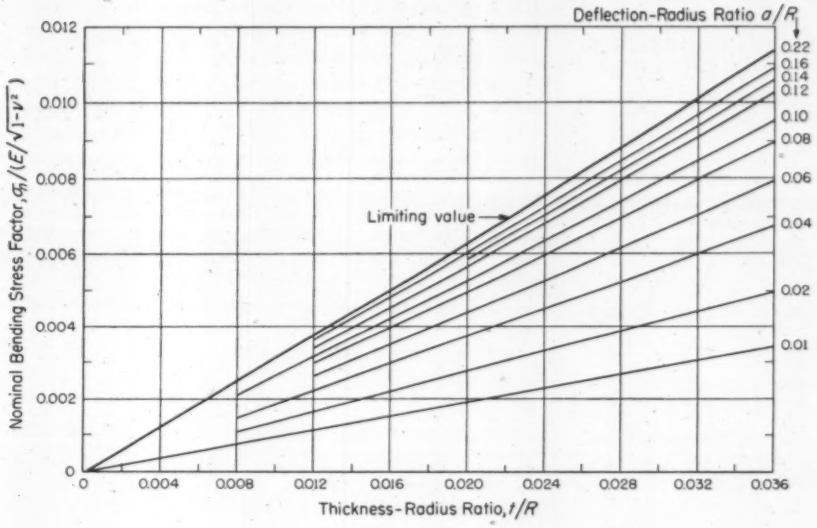
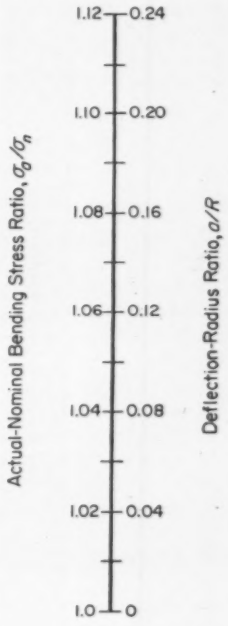


Fig. 4—Left—Instability chart for nominal bending stress

Fig. 5—Below—Chart for ratio of actual to nominal bending stresses



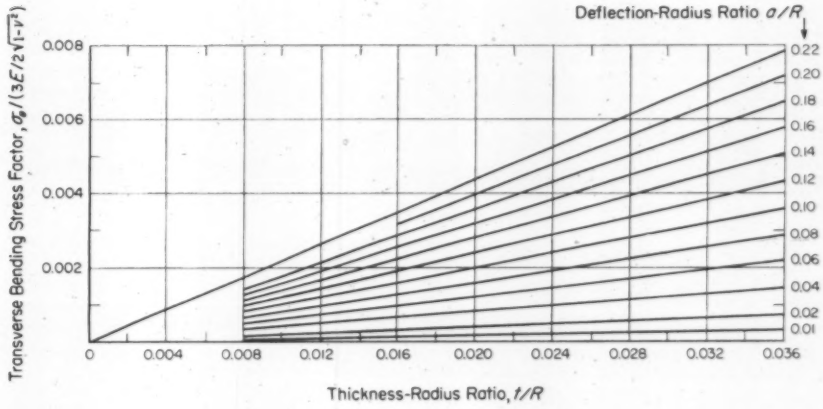


Fig. 6—Left—Instability chart for transverse bending stress

$$M = \frac{\pi E R^2 t}{\sqrt{1-\nu^2}} \sqrt{\frac{a}{R}} \left(1 - \frac{3a}{2R}\right) \frac{t}{R} \tag{4}$$

From the assumption of inextensibility, the transverse bending moment is

$$M_\theta = \frac{aEt^3}{4R^2(1-\nu^2)} \cos 2\theta \tag{5}$$

In a like manner, the actual moment of inertia of the section in the flattened condition is

$$I_a = \pi R^3 t \left(1 - \frac{3a}{2R}\right) \tag{6}$$

The nominal bending stress at which instability occurs is obtained from Equation 4:

$$\sigma_n = \frac{M}{Z_o} = \frac{E}{\sqrt{1-\nu^2}} \sqrt{\frac{a}{R}} \left(1 - \frac{3a}{2R}\right) \frac{t}{R} \tag{7}$$

Equation 7 is of practical significance, since the unit radial displacement or flattening is obtained from a known nominal bending-stress for any value of t/R. This relationship is shown by the family of curves in Fig. 4. In addition, Equation 4 shows that the limiting bending moment which causes collapse occurs when $a = 2R/9$. Thus, if the nominal bending-stress for a particular t/R ratio is such that it falls outside the range of the limiting curve, Fig. 4, the cross sections will collapse.

The deformation of the cross section at the point of collapse is obtained from Equations 1 and 2:

$$v = 0.11R \sin 2\theta \tag{8}$$

$$w = 0.22R \cos 2\theta \tag{9}$$

The concept of nominal stress used to establish the stability criteria, can be used to determine the

maximum actual stresses:

$$\sigma_a = \frac{M}{I_a}(R - a) \tag{10}$$

$$\sigma_n = \frac{M}{I_o} R \tag{11}$$

From Equations 10 and 11, a ratio of the maximum actual to maximum nominal bending-stresses is obtained:

$$\frac{\sigma_a}{\sigma_n} = \frac{I_o(R - a)}{I_a R} = \frac{1 - \frac{a}{R}}{1 - \frac{3a}{2R}} = 1 + \frac{a}{2R} \tag{12}$$

The actual stress for any stage in the deformation of the cross section can be calculated from Equation 12. Hence, at the point of collapse, when $a = 2R/9$, the actual axial stress is $\sigma_a = 1.11\ \sigma_n$. The ratio obtained from Equation 12 is shown in Fig. 5.

From Equation 5, it can be seen that the transverse bending reaches a maximum at $\theta = 0$, and the corresponding maximum stress is

$$\sigma_{t,max} = \frac{3E}{2(1 - \nu^2)} \left(\frac{a}{R}\right)\left(\frac{t}{R}\right) \tag{13}$$

The curves for transverse bending-stress, Equation 13, are shown in Fig. 6.

Design Note: Although the foregoing analysis was used to find the bending stability of an annular ring of a thin-walled circular cross section, the curves obtained are fully applicable to straight tubular members as shown in the design example. The difference between the simple theory of bending and the foregoing analysis is emphasized by the fact that the second term appearing in Equation 3 has the effect of depressing the bending-moment curve below that given by simple theory, Fig. 1. The maximum bending moment that occurs when $a = 2R/9$ corresponds to point P on the curve, and if this maximum is not exceeded, a state of initial instability will exist. A bending moment in excess of the maximum causes collapse of the cross section.

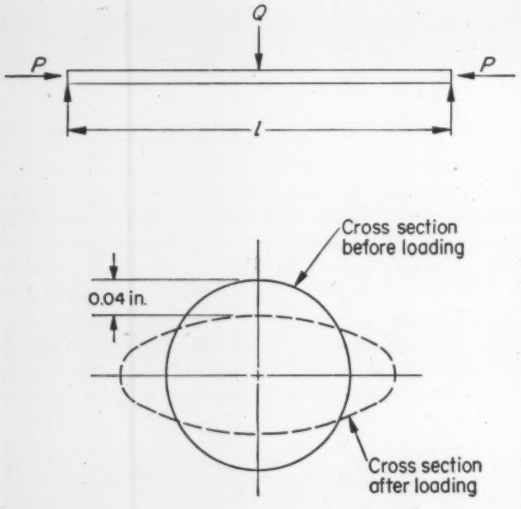


Fig. 7—Typical example of tubular beam in which cross section deforms under load

Design Example: To illustrate the application of the previous analysis, consider the case of a tubular beam of thin-walled circular cross section loaded as shown in Fig. 7. Assume that load $Q = 1000$ lb, $l = 24$ in., $R = 1.0$ in., $t = 0.02$ in., and $E = 30 \times 10^6$ psi.

The maximum bending moment in the beam due to load Q is

$$M_{max} = \frac{Ql}{4} \frac{\tan u}{u} \tag{14}$$

where

$$u = \frac{\pi}{2}\sqrt{\frac{P}{P_{cr}}}$$

If P/P_{cr} is assumed equal to $1/4$, then $\mu = \pi/4$ and Equation 14 reduces to

$$M_{max} = \frac{Ql}{\pi} \tag{15}$$

From Equation 15, the maximum moment for the beam is $M_{max} = 1000(24)/\pi = 24{,}000/\pi$ lb-in., and the bending stress obtained from the simple theory on bending is $\sigma_n = M_{max}\, R/I = 24{,}000(1)/\pi^2\ (1)(0.02) = 120{,}000$ psi, where $I = \pi R^3 t$. Hence,

$$\frac{\sigma_n}{E/\sqrt{1 - \nu^2}} = \frac{120{,}000}{30(10^6)/0.95} = 0.0038$$

The intersection of this value with the ordinate of $t/R = 0.02$, Fig. 4, lies below the limiting value curve, and therefore, collapse of the cross section will not occur.

However, in Fig. 4, the intersection lies on $a/R = 0.04$, which indicates that the cross section is not circular any longer and that the maximum deflection is 0.04 in., Fig. 7. Hence the bending stress is in excess of that calculated from the simple theory of bending, and the actual stress is obtained from Fig. 4. Ratio $a/R = 0.04$; hence, $\sigma_a/\sigma_n = 1.018$, and the actual stress is $\sigma_a = 1.018(120{,}000) = 122{,}000$ psi.

Results of the foregoing analysis show that the beam may be reduced to a wall thickness of 0.018 in. and a radius of 0.75 in. Following a procedure similar to the initial analysis, $t/R = 0.024$, $\sigma_n = 236{,}000$ psi, and

$$\frac{\sigma_n}{E/\sqrt{1 - \nu^2}} = 0.0075$$

From Fig. 4 it is seen that the nominal bending-stress ratio for $t/R = 0.024$ lies on the limiting curve. Hence, the section is at the point of collapse. For this condition, the actual bending stress from Fig. 5 is $\sigma_a = 1.104\ \sigma_n = 262{,}000$ psi.

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How to design

Aluminum Impact Extrusions

By MARK A. ZIEGLER
Impact Project Engineer
Aluminum Co. of America
Edgewater, N.J.

THE impact process is a method for fabricating parts in aluminum by combining, in effect, the extrusion and forging processes in a single operation. Physical characteristics of impact parts are similar to those of extruded and forged products.

The Impact Operation: Virtually all impacts are produced in one operation by basic tooling consisting of a moving punch and stationary die. A closely controlled volume of aluminum, in a predetermined shape or "slug," provides a reservoir of metal from which the part is fabricated.

Impact pressure is exerted on the slug by the rapidly moving punch which enters the die cavity and partially closes the die opening. An orifice is thus formed in the shape of the cross-section of the required part.

Under continued pressure, the metal flows through the orifice and forms the sidewall of the part by extrusion. The metal which has not been extruded at the end of the press stroke forms the forged section of the part.

Metal flow during impact can be either forward or reverse, i.e., either in the same or opposite direction as that of punch movement. A third type of tooling permits simultaneous forward and reverse extrusion. From a combination of these basic types of tooling, a wide variety of design shapes is possible, Fig. 1.

Depth of Part: The length or depth of an impact is limited only by the capacity of the press and by the strength of available tool steels. Aluminum will flow out of the

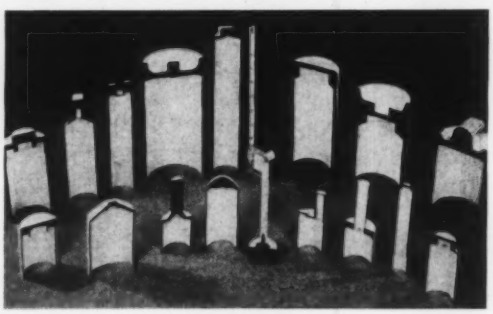

Fig. 1 — Typical closed-end aluminum impacts. Such parts are simple to achieve from design and production standpoints. Integral bosses and tubular extensions are produced in a single operation and eliminate the necessity for expensive assembling techniques

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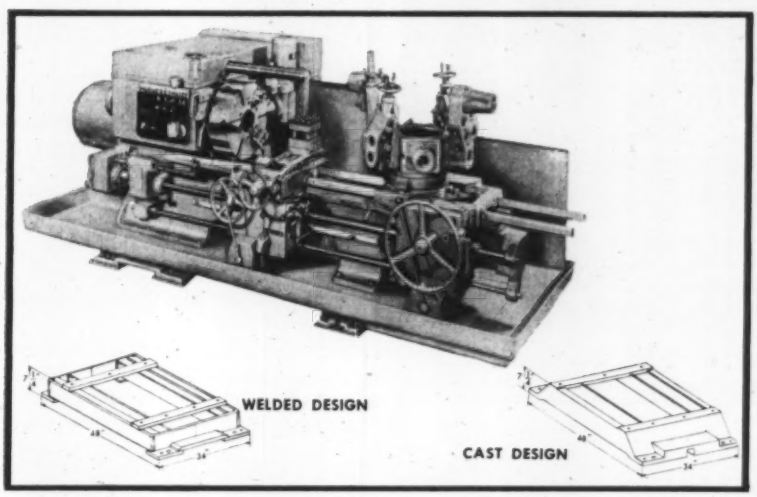

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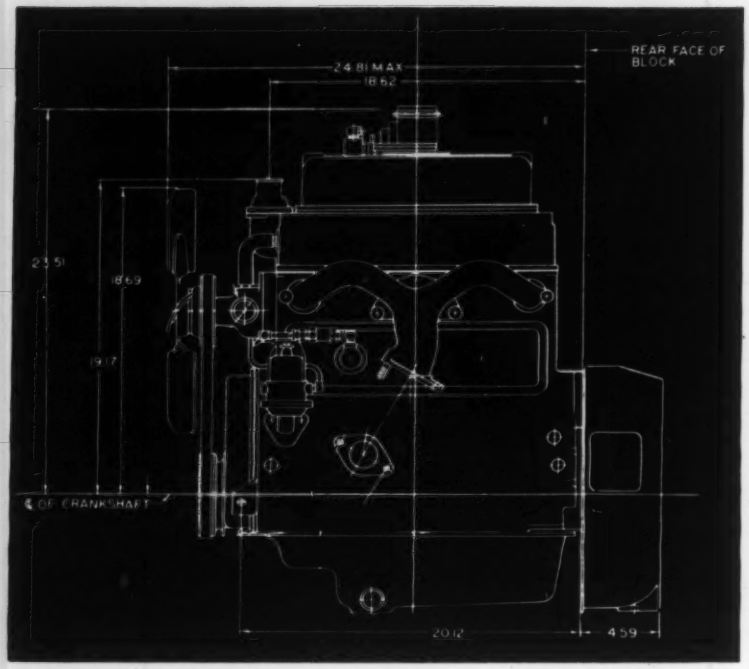

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die as long as there is a reservoir of metal in the cavity and force is exerted by the punch. When cold slugs are used, work hardening of the aluminum takes place, but is kept from being excessive by heat generated during impact.

In reverse extrusion, strength characteristics of the punch often determine the maximum length which can be produced. In terms of diameter of the impact, maximum length is generally 10 to 12 diameters. Lengths to 18 diameters have been produced successfully in certain applications.

Materials: Impacts are produced in a wide range of aluminum alloys. Work-hardening materials such as 1100 and 3003 alloys are produced at minimum cost and offer adequate properties for many applications. When greater strength and improved machinability are required, alloys such as 6061 and 6151, in the T-6 temper, are specified. Alloys 2014-T6 and 7075-T6 are generally used for applications requiring high strength.

Although a number of additional alloys are acceptable for the impact process, experience has shown that the alloys mentioned provide a fairly complete selection of aluminum properties for most designs.

Tolerances: Impacts are inherently free of draft—a feature that is one of the most important attributes of the process. Tolerances on impact dimensions depend on size and shape of the part, alloy used, required wall thickness, and type of tooling. In general, wall-thickness variations of 0.002 or 0.003 in. are common for small-diameter, light-wall applications. For parts of extreme size and high-strength material, wall-thickness variations may increase to 0.010 to 0.015 in.

Tolerances on diameters are held to 0.003 in. in production on small parts but, again, may increase to 0.010 to 0.015 in. for large, high-strength parts. Pressure dimensions, which are highly influenced by many variables, are often in the range of 0.008 to 0.015 in.

Impact Designs: Wide latitude is permissible in the design of the sidewall or extruded section of an im-

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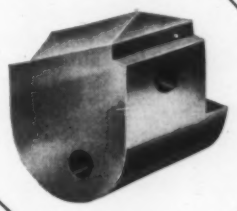
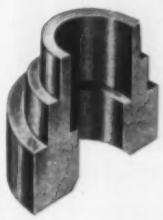
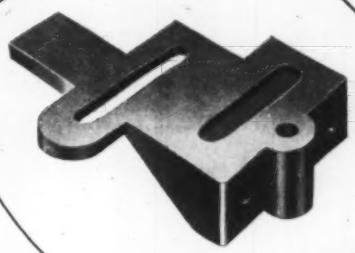
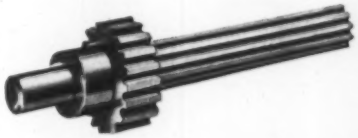
V-R Carbides...









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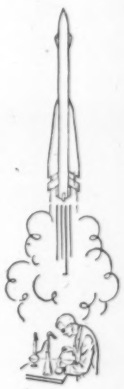

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pact. Round shapes usually lend themselves best to simple production methods. However, oval, square, and rectangular, as well as many special shapes, are readily produced. Symmetry of cross-section is important and does much to simplify the fabrication of impacts, but it is by no means essential in all cases. Nonsymmetrical shapes have been produced, although designs are somewhat limited in this respect, Fig. 2.

Longitudinal ribs can be incorporated in the sidewall of impacts by modifying tooling to provide an appropriate extrusion orifice. Ribbing can be on either the inside or the outside of the piece and has, on occasion, even covered the bottom of impacts, Fig. 3.

Lugs, bosses, grooves, and depressions can be incorporated on both surfaces of the pressure section of an impact. Here again, symmetry of design helps the fabrica-

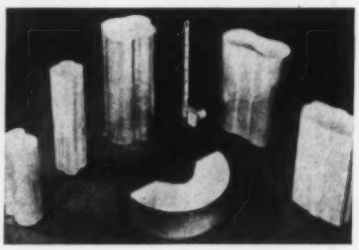

Fig. 2—Impacts with special cross-sections some of which depart from complete symmetry. Although symmetrical cross-sections do much to simplify fabrication of impacts, they are not essential for a reliable product

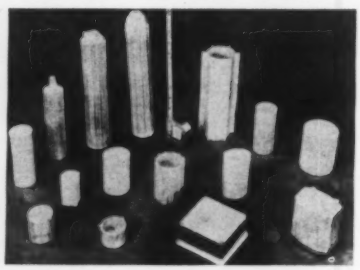

Fig. 3—Types of decorative and functional ribs commonly designed into impacts. Internal or external ribbing is produced by modifying tooling to provide an appropriate orifice. For special applications, ribs have been produced at the bottom of impacts

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... And, every Setko Self-Locking set screw is an *ace* performer! Each one depends on a specific design principle to lock fast.

They provide positive locking action ... speed assembly and cut costs by utilizing standard driving techniques ... don't require special tapping. All are available in regular points, patented Nu-Cup point, and standard sizes and threads. With the Setko System, they can be hopper-fed in sizes as small as #2 (.086" x 1/8").

ZIP-GRIP® SET SCREWS
Exclusive Contra-Thrust action locks at any point. Solves problems of loosening due to wear, clearance in the thread, or vibration. Can be re-used.

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When driven, two offset edges in threaded portion exert powerful spring pressure. Not affected by extreme variations in tapped holes.

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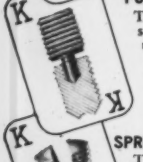

POINT-LOK SET SCREWS
This design ends top-screw loosening on two-screw applications. Lower screw can be locked with Point-Lok without disturbing original setting. Can be re-used.

SPRED-LOK® SET SCREWS
This design is for soft metal applications. Top is "spread" slightly to take up "flow" of soft metal. Can be re-used.

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Circle 518 on Page 19

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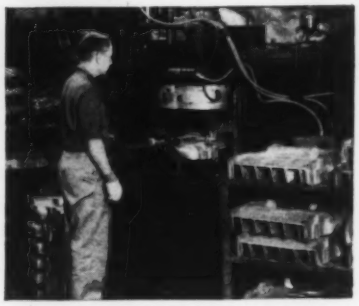

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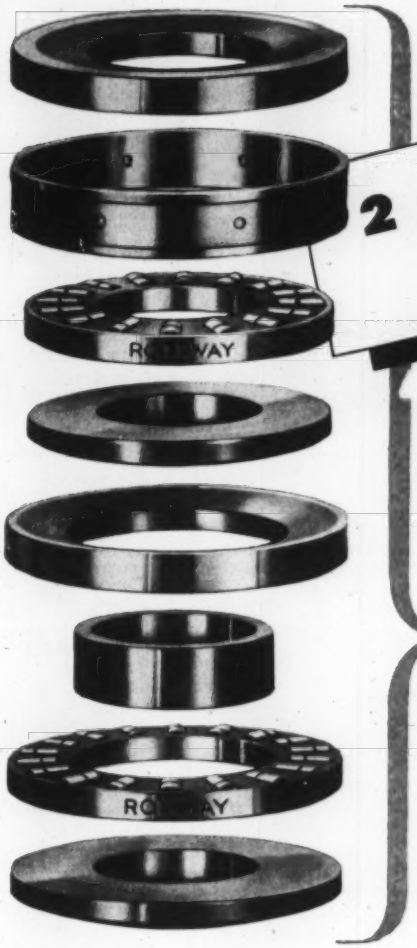

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8 to 12 times
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New ROLLWAY
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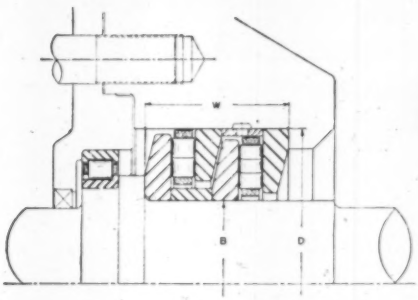
Using axial space along the shaft, rather than enlarging the housing diameter, this new Rollway tandem thrust bearing distributes the load over two or three stages of roller components. Gives 2 to 3 times more thrust capacity than conventional thrust bearings. Life expectancy is 8 to 12 times longer depending upon the number of stages.

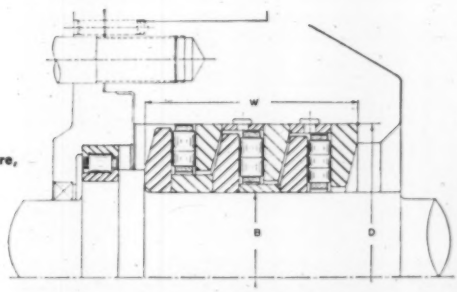
Each stage comprises a rotatable bearing plate . . . a bronze retainer with thru-hardened steel rollers... a compression sleeve... and a stationary bearing plate. The thrust load is applied to the first stage and is by-passed by each compression sleeve in turn to the remaining stage or stages.

Calculated deformation of the bearing plates distributes the load uniformly on all rollers. A greater number of rollers in the first stage carries about 60% of the load, without increasing the load per roller. Compression sleeves have cross-sectional areas proportional to the load imposed. Roller variance is held within one ten-thousandth inch.



TWO STAGE TANDEM

22 sizes, up to 17" bore, 34" O.D., and 2,325,000 lb. capacity at 100 rpm



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Tandem Thrust Bearing manufactured by Rollway Bearing Company, Inc. under U.S. Patent Number 2,374,820.

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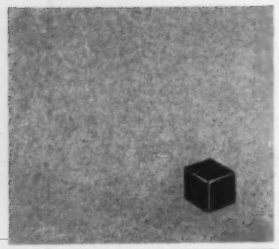
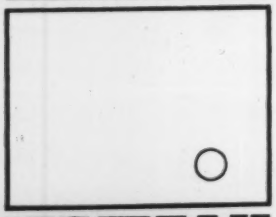
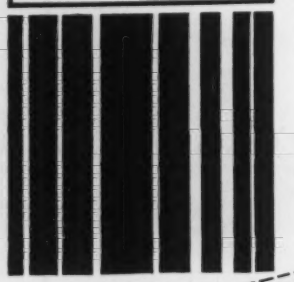


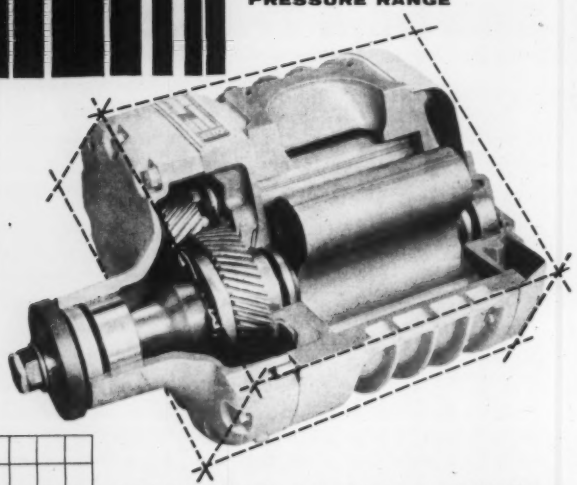
SMALLEST CUBE DIMENSIONS

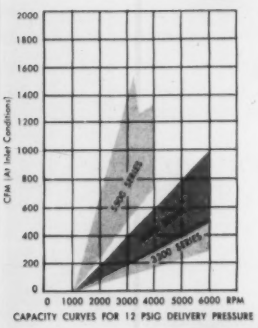


LIGHTEST WEIGHT



WIDEST PRESSURE RANGE





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If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 11 production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.

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tion and is desirable. If nonsymmetrical designs cannot be avoided, it is often possible to devise methods of minimizing their effect.

The impact process is an economical and reliable method for producing housings and cylinders for pressure-tight applications. The ability of the process to provide integral bosses and tubular extensions offers savings by eliminating welding or brazing operations. It is often desirable to provide material for threading or tapping the open end of a pressure cylinder to obtain a proper closure. The impact technique can provide a part with extra thickness at the open end.

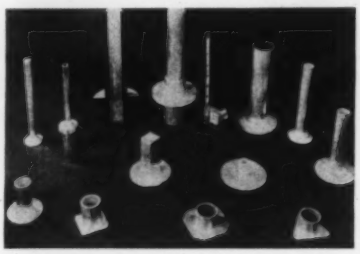


Fig. 4—Light-wall tubing and heavy flange ends combined in one-piece impacts. This technique eliminates distortion and buckling of tubing which might occur with other assembly methods

Multiple-wall impacts as substitutes for welded or mechanically joined components simplify many assembly problems. Light-wall tubing and heavy flange ends can be produced easily in a single part, Fig. 4. Other methods of fabrication generally require complicated assembly at higher costs.

ASM paper, "Designing in Aluminum for the Impact Process," Proceedings of the Southwestern Metal Congress, Dallas, Tex., 1958; *pp.* 24-30.

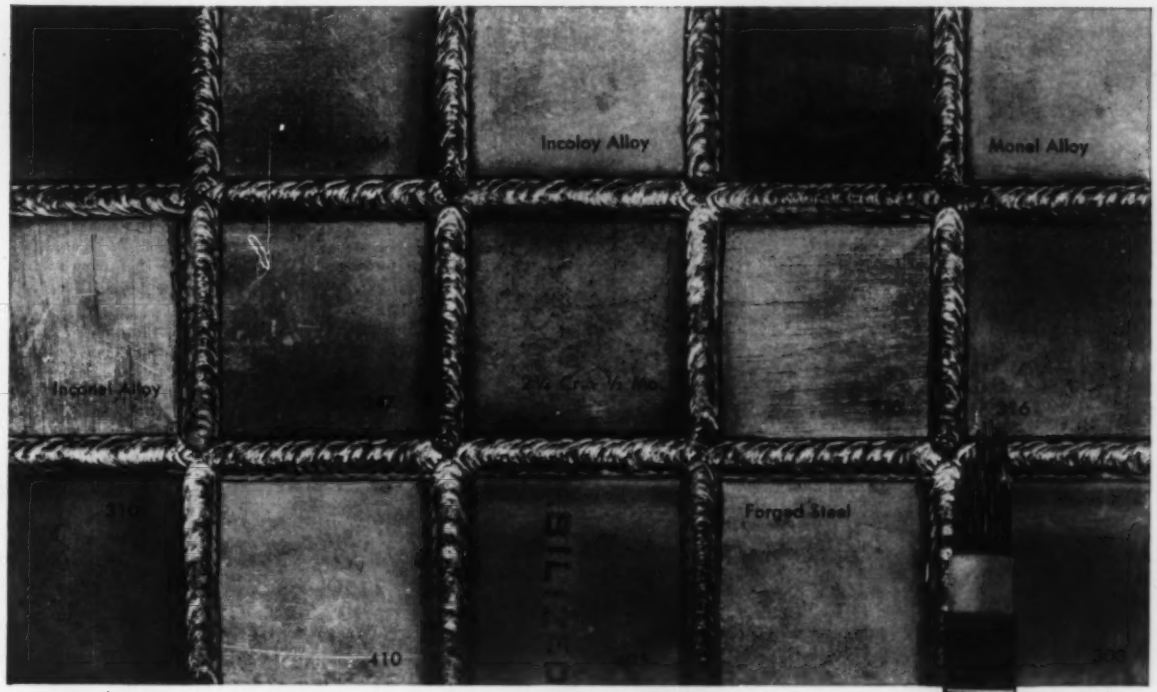
materials

Thermal and Mechanical Fatigue Of Nickel and Titanium

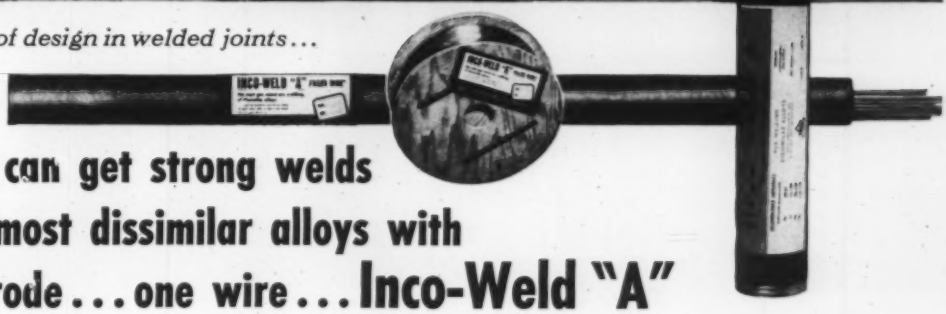
H. Majors Jr., Seattle University School of Engineering

Results of thermal and load-cycling tests on 0.5-in. ID thin-walled tubes of titanium and nickel in direct

Circle 521 on Page 19



New freedom of design in welded joints...



Now you can get strong welds between most dissimilar alloys with one electrode... one wire... Inco-Weld "A"

No longer do you need to avoid designs involving welded joints between dissimilar alloys.

With Inco-Weld* "A" Electrode or Inco-Weld "A" Wire you can rely on sound production welds in better than 97% of dissimilar alloy combinations involving ferritic and austenitic stainless steels, low alloy steels, mild steels, high nickel alloys and other alloys.

Inco-Weld "A" Electrode and Wire assure you of strong, ductile joints suitable for severe service . . . welds of X-ray quality... made without special training or techniques.

Corrosion resistance of joints usually equals or exceeds that of the base metal. With Inco-Weld "A" Wire, the deposit can be age-hardened.

Don't hesitate to design in dissimilar alloys . . . keep Inco-Weld "A" versatility in mind.

For technical data and case history evidence showing how others use Inco-Weld "A" Electrode and Wire successfully, send for folder "Now You Can Weld Dissimilar Alloys." Write The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

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THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street — New York 5, N. Y.

SOME OTHER DISSIMILAR METALS SUCCESSFULLY WELDED WITH INCO-WELD "A" WIRE

Plate Material	Thickness	Plate Material	Thickness
304 to Monel Alloy	.078"	Nickel to SA-285	.062"
304 to Carbon Steel	.078"	Inconel Alloy to Hastelloy "C" Alloy	.078"
Carbon Steel to Monel Alloy	.078"	10% Ni-Clad-Steel to 10% Ni-Clad-Steel	¼"
Carbon Steel to Inconel Alloy	⅜"	3½% Ni-Steel to 3½% Ni-Steel	½"

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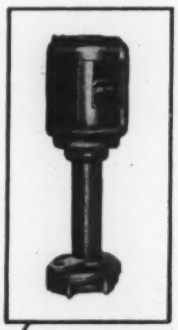
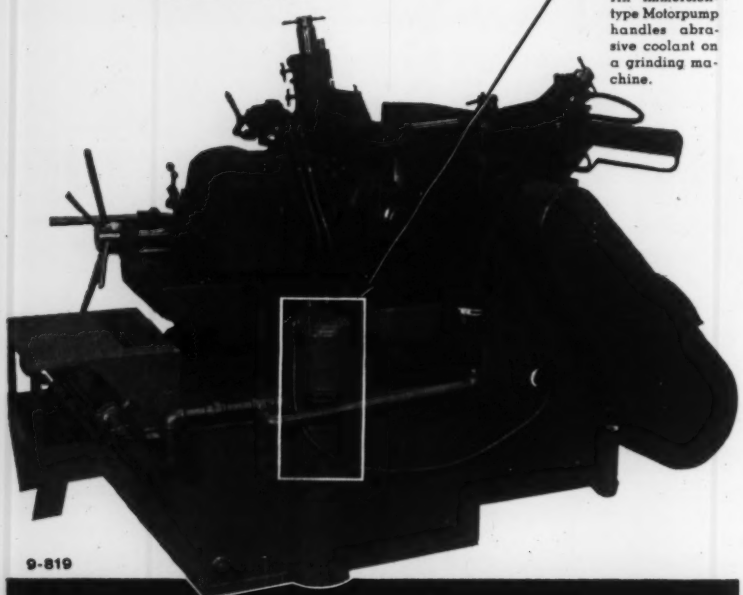


An immersion-type Motorpump handles abrasive coolant on a grinding machine.



9-819

Ingersoll-Rand / 11 Broadway, New York 4, N.Y.

loading under a constant mean temperature to obtain stresses and plastic strains. Type A nickel and Ti-75A were tested at mean temperatures of 525 and 575 F respectively to avoid phase changes during cycling. Data permit a comparison of load-cycling and thermal-cycling fatigue to be made in terms of either stress or strain. For titanium, in the region of 3000 to 10,000 cycles of stress reversal, there is no large effect. Beyond 12,000 cycles of stress reversal, titanium must be stressed less in thermal cycling than in load cycling to achieve the same life to failure. Plastic strain sustained under thermal cycling is very much less than in load cycling. For the same mean temperature and life to rupture, type A nickel under load cycling can absorb twice the plastic strain absorbed in a thermal-cycle test. Type Ti-75A titanium under load cycling can absorb $5\frac{1}{2}$ times the plastic strain of a thermal-cycle test.

ASM paper 105, *ASM Fortieth Annual Convention, Cleveland,* 1958, 12 *pp.*

High-Temperature Stability Of Titanium Alloys

M. L. Greenlee, G. A. Lenning, W. M. Parris, and H. D. Kessler, Titanium Metals Corporation of America

Effects of heat treatment on unnotched and notched tensile properties, notch-bend impact strength, and high-temperature stress stability of three commercial titanium alloys. Appreciable increases in room and high-temperature strength and creep resistance are realized from heat treatment without impairing these properties. Alloys tested include Ti-140A, Ti-155A, and Ti-6Al-4V. These alloys are widely used, and a considerable amount of experience with them has been accumulated in the annealed and heat treated conditions. Maximum room-temperature strength increases obtained with heat treatment of the $\frac{5}{8}$-in. round specimens are approximately 65,000 psi for the Ti-140A, 75,000 psi for Ti-155A, and 25,000 psi for the Ti-6Al-4V alloy. Results indicate that notched and unnotched ductility and stability considerations may impose limits on the amount of strength increase desired for the Ti-140A and Ti-155A alloys depending on the application. On an equivalent strength-weight

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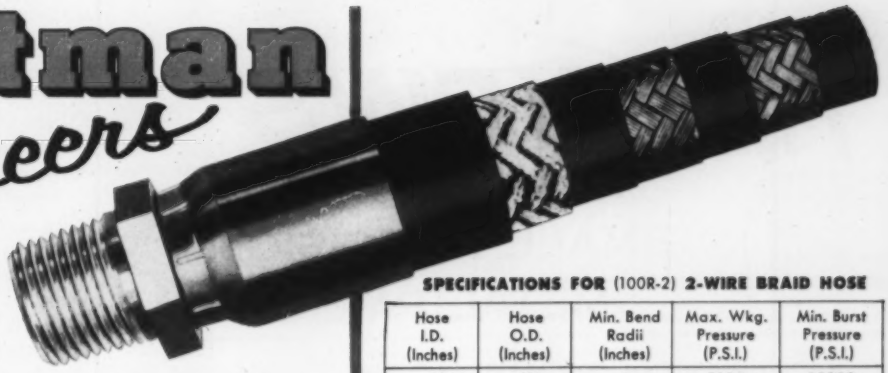
engineers the way TO HIGHER PRESSURES



Eastman engineering is making possible ever-increasing advances in hydraulic pressures through:

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- Hydraulic application of couplings to hose, assuring maximum grip—within specified hose tolerance.
- Maximum orifice—designed to improve fluid flow, reduce friction and increase power delivery.
- More rigid testing of completed assemblies to reveal additional opportunities for improvement.

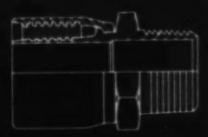
Let Eastman engineers help you increase the "power-performance ratio" of your product to improve your competitive position in your field.

SPECIFICATIONS FOR (100R-2) 2-WIRE BRAID HOSE

Hose I.D. (Inches)	Hose O.D. (Inches)	Min. Bend Radii (Inches)	Max. Wkg. Pressure (P.S.I.)	Min. Burst Pressure (P.S.I.)
¼	11/16	4	5000	20000
⅜	27/32	5	4000	16000
½	31/32	7	3500	14000
¾	1 ¼	9½	2250	9000
1	1 5/16	9½	1875	7500
1 ¼	2	16	1625	6500
1 ½	2 ¼	20	1250	5000
2	2 ¾	22	1125	4500

PERMANENTLY ATTACHED COUPLINGS

For 2-wire braid hose. Offers maximum coupling strength, strong hose attachment and improved orifice for rapid, friction-free fluid flow. For working pressures up to 5000 psi. See Pages 10 and 11.

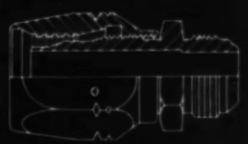


HIGH PRESSURE COUPLINGS

For EXTREME high pressures up to 7000 psi working pressure. Eastman engineered for greater power delivery and performance. For specifications and sizes, send for New Eastman Bulletin 200, below.

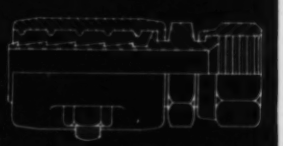
2-PIECE REUSABLE COUPLINGS

For 2-wire high pressure hose up to 5000 psi working pressure. Increases serviceability of your equipment through easy replacement in the field. See new Bulletin for complete details.



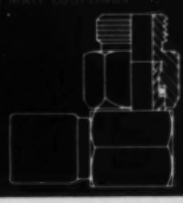
CLAMP TYPE COUPLINGS

Accurate machining assures alternate positioning of clamp ribs between each barb of insert—creating exclusive Inter-Lock grip—available to you only through Eastman. Pages 14 and 15.



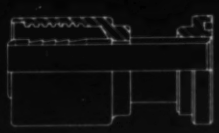
MALE "O" RING SEAT COUPLINGS

Permits easy assembly in close quarters, easy positioning of hose in 45° and 90° angles. Economical, reduces number of threaded connections. Dimensional drawings, sizes, and specifications in new Bulletin.



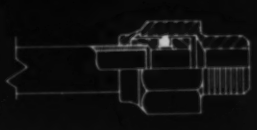
FLANGE HEAD COUPLINGS

Offer advantages of permanent hose attachment plus Split Flange Head Couplings with 0° to 90° stems. Economy plus user convenience. Specifications and sizes listed in new Bulletin.



TUBING ASSEMBLIES

Swivel Male "O" Ring Tube Nut used on tubing assemblies. Eastman offers formed tubing with beaded or flared ends—to your requirements. Specifications and sizes on Page 30.



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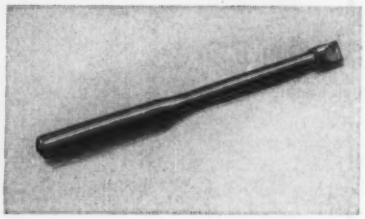
Circle 523 on Page 19

NEWS
from Torrington on
SMALL PRECISION METAL PARTS

Ordinarily, one would not think of "custom manufacture" and "mass production" in the same breath. Except at Torrington's Specialties Division, where the production of tremendous varieties and quantities of small metal parts of exceptional precision and uniformity is a day-to-day occurrence.



A good example is the valve stem we make for a leading pump manufacturer. Operations include turning, threading, slotting and tempering. Nothing unusual about that, except that Torrington can do it to such precision that the specified finish of 4 to 6 micro-inches is achieved without grinding. This saves our time—and our customer's money, yet every part is produced to perfection.

Another interesting case is an insulated contact pin. It is driven into wood to check moisture content by electrical conductivity. The reduced center section is insulated. The shank must be accurate to ±.0005", and the diameter of the tapered neck to +.005", −.000". Torrington's engineers devised a way to back-swage the neck to required taper and trim square between head and reduced section *automatically*.

The manufacture of such parts as these, in the tremendous quantities required of us every day, demands highly specialized engineering skills. To serve you most efficiently, our Specialties Division maintains a separate engineering department. Staffed with engineers who have wide experience in precision metalworking, the department can help you with any engineering problems that might arise

in the manufacture of your special metal parts. For prompt service, just circle our number on the reply card, call our area salesman or write direct to:

The Torrington Company, Specialties Division, 626 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings

ratio basis, 170,000 psi in titanium corresponds to approximately 290,000 psi in steel. The notch tensile-ratio obtained is about 1.3 for this strength level. On the basis of conditions of heat treatment and properties studied, no definite advantage is indicated for high or low-temperature aging treatment. In regard to solution temperature for the Ti-140A alloy, better stress-stability characteristics are obtained at 1400 F; whereas a slightly more favorable relation between notch tensile-ratio and tensile strength was obtained at 1480 F. No similar effect of solution temperature was observed for the Ti-155A and Ti-6Al-4V alloys.

ASM paper 94, *ASM Fortieth Annual Convention, Cleveland,* 1958; 18 *pp.*

mechanical

Designing Spur Gears Of Zytel Nylon Resin

K. W. Hall and H. H. Alvord, University of Michigan

A method for calculating the load-carrying capacity of spur gears made of Zytel nylon resins, and a summary of work done to establish reliable design methods for gears made of this material. Various configurations of test gears with hob-cut teeth and molded from Zytel 101 were life tested to failure. Causes of failure are analyzed and recommendations made for design improvements. Design problems are covered in examples which require finding pitch diameter, influence of design by processing, lubricant considerations, and torque requirements. Design recommendations cover size of teeth, pressure angle and tooth form, manufacturing tolerances, backlash, gear proportions, and treatment after molding.

ASME paper 58-A-209, *ASME Annual Meeting, New York, December,* 1958; 13 *pp.*

Ducted-Fan Design Theory

T. G. VanNiekerk, National Mechanical Engineering Research Institute, Pretoria, South Africa

A theory which makes possible design of ducted fans directly by establishing optimum fan parameters which otherwise would have to be chosen somewhat arbitrarily. While rational, the theory introduces a concept of annulus efficiency that

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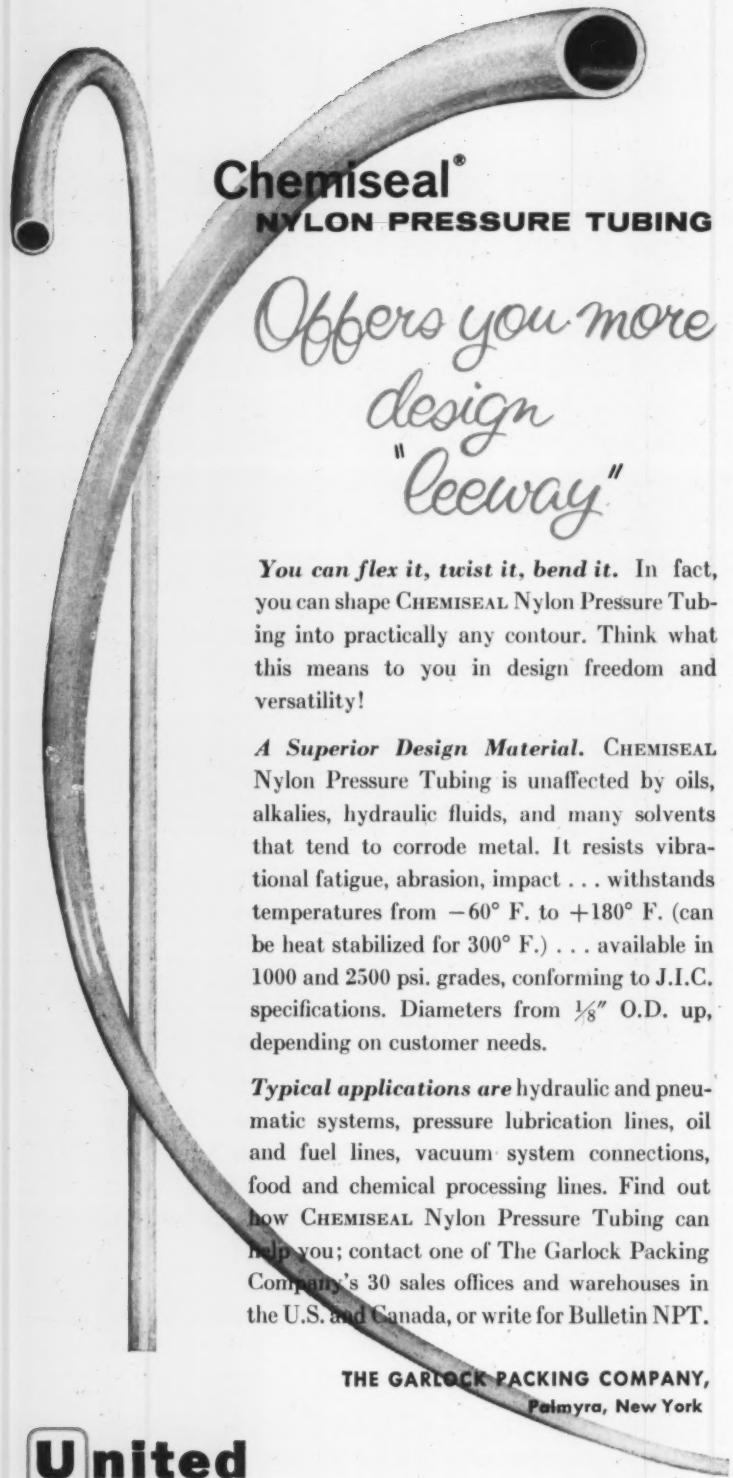
Circle 525 on Page 19



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THE GARLOCK PACKING COMPANY,
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is still empirical. In its present form, the theory is limited to the case where pressure rise and axial air velocity are considered constant over the fan annulus. However, it seems possible to extend the analysis to make it applicable where these quantities vary. Establishing optimum fan parameters depends to some extent on the degree of accuracy with which certain losses, here termed annulus losses, can be estimated. Direct calculation of blade solidities and blade angles is accomplished by means of a basic equation which is only slightly effected by large errors in the only estimated variable in the equation. The design of two fans, one having inlet guide vanes and the other having straightening vanes often used in wind tunnels, are covered by examples.

ASME paper 58-A-4, *ASME Annual Meeting, New York, December,* 1958; 7 *pp.*

Flow-Induced Noise In Heat Exchangers

A. A. Putnam, Battelle Memorial Institute

An outline of causes of noise generation in heat exchangers and problems which result from the phenomenon of vortex shedding. Type of noise discussed is generated by three mechanisms. First, the natural frequency of vortex shedding at a particular flow rate is close to a natural acoustical frequency of the heat exchanger. The two systems thus couple, and kinetic energy in the flow stream is converted into acoustic pressure waves. Not only can the noise be intense, but walls can buckle under the pressure effects. Second, the natural frequency of the heat exchanger tubes may be the natural vortex-shedding frequency of these heat-exchanger elements. Here, the tube will start to vibrate and reinforce the vortex shedding. Results are severe noise and fatigue or structural failures. Third, a condition can exist where the vortex-shedding frequency, tube frequency, and acoustic frequency of the system all couple together. These problems are related to cleaner design of heat exchangers which lead to a decrease of relative acoustic-damping losses within. The three mechanisms of noise generation are covered in detail, and several suggestions for handling these problems are includ-

Circle 526 on Page 19

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Circle 527 on Page 19

ed for evaluation.

ASME paper 58-A-103, *ASME Annual Meeting, New York, December,* 1958; 4 *pp.*

techniques

Time-Temperature Parameters Applied to Creep-Rupture Tests

S. S. Manson, G. Succop, and W. F. Brown Jr., NASA

How to apply time-temperature parameters in determining isothermal creep-rupture curves for an alloy when no previous data exist. Parameter constants and master curves are determined over a wide stress range with a minimum expenditure of test time. Isothermals are developed for a ferritic Cr-Mo-V alloy and an austenitic Cr-Ni-Mo alloy. Results of the calculations are compared with isothermal data established by conventional test procedures for a ferritic and austenitic alloy with emphasis on savings in test time. A number of different relations have been suggested in the past for extrapolation and interpolation of creep-rupture data. Several of these are particularly attractive from an engineering point of view since they place no restriction on the structural stability of the alloy. This investigation describes a procedure designed to minimize the amount of testing required to establish parametric constants. Specifically, the general form of the parameters is examined for their implications regarding material behavior and, therefore, the types of tests required to determine master curves. The procedure minimizes factors of human judgment in data analysis.

ASM paper 106, *ASM Fortieth Annual Convention, Cleveland,* 1958; 15 *pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASM—American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; paper 40 cents, to members, 80 cents to nonmembers.

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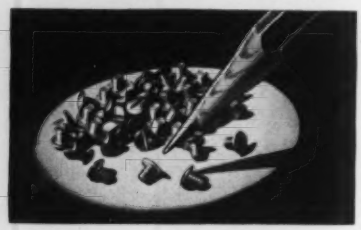

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THE PART:
Special 1-64 Miniature Binding Screw

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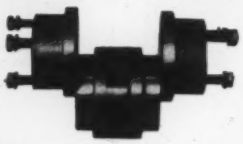
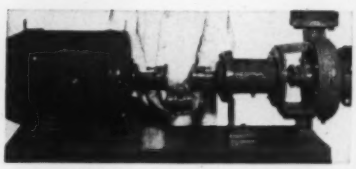
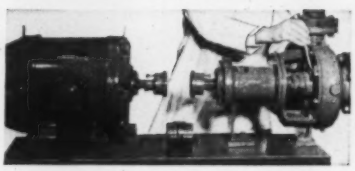


This economical coupling provides quick, easy disconnection from driving unit without disturbing drive shaft or piping. Permits removal of equipment from line in three simple steps (see below). Only two sets of bolts need be removed. Axial movement of shafts is not required.

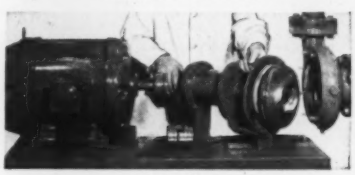
The RRL Coupling is ideal for installation on split-case pumps, diesel or gas engines, multiple generator sets and other drives requiring rapid disconnect without disturbing the line.



Unbolt and remove coupling.



Unbolt back head and cradle combination assembly from casing.



Remove pump for inspection or repair. Line remains intact.

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Circle 529 on Page 19

Many a manufacturer reports that installing a Fenwal THERMOSWITCH unit resulted in *immediate improvement in the performance of his equipment!*

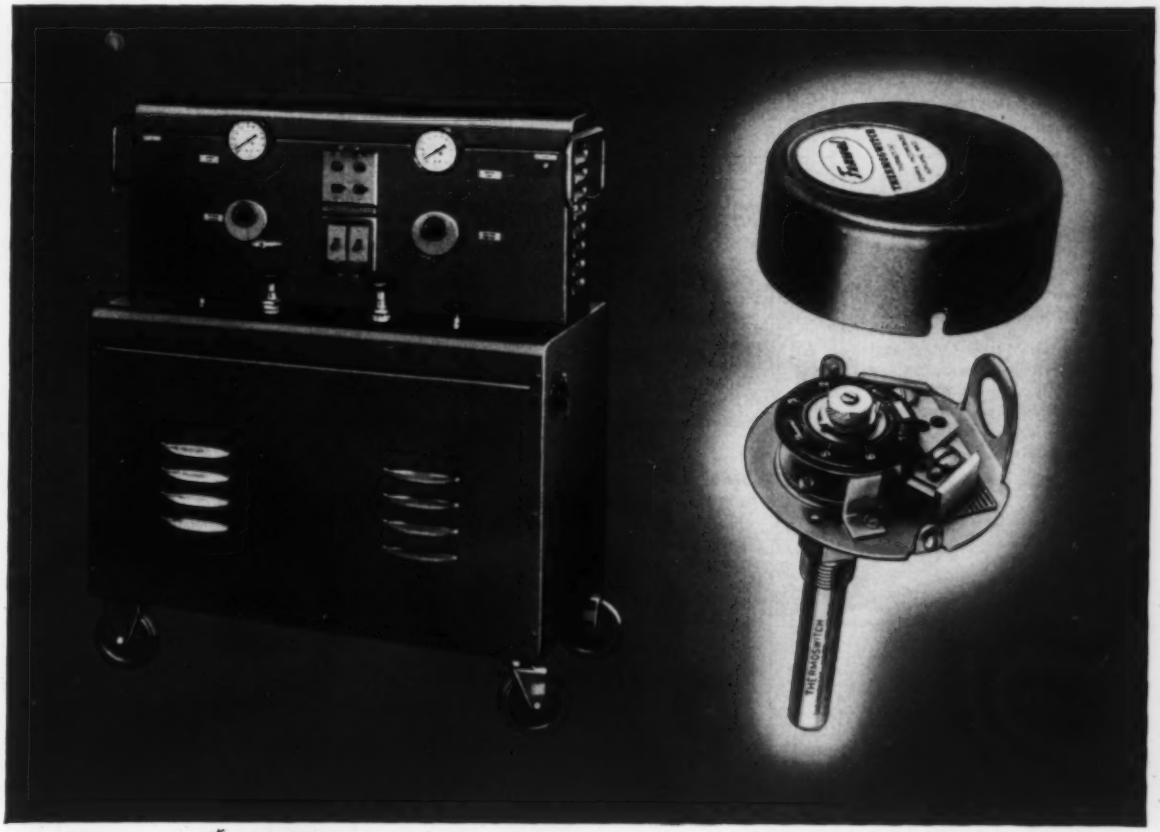
"Immediate" is right. Rapid response is one big advantage because the outer shell is the temperature sensing member. Extreme sensitivity — within a fraction of a degree — is another. That's because the slightest movement of the shell opens or closes contacts. And within its operating range, a THERMOSWITCH unit is field adjustable, yet has a sealed tamper-proof assembly to retain its sensitivity and precision through a long, useful life. Operating range is from −100°F to 600°F . . . *three to five times that of any ordinary thermostat!*

Applications for easy-to-install THERMOSWITCH units are virtually limitless . . . not only to "tone up" existing thermal systems, but to insure the long, reliable life that industry requires. For more facts write to Fenwal Incorporated, 193 Pleasant Street, Ashland, Mass., asking for a catalog, a sales engineer, or both.

Tone Up Your System

. . . any thermal system . . . with a sensitive, precise THERMOSWITCH® unit

In this Sterlco Control, an automatic self-contained unit for heating or cooling water to maintain a constant temperature while circulating it continuously through a plastics forming mold, "a Fenwal THERMOSWITCH unit, No. 17800 with dial and knob, fills our requirement for a sensitive, reliable, long-lasting thermostat." So says Sterling, Inc., Milwaukee, Wis.



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Circle 531 on Page 19

Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Variable Speed Drives

Data on a complete line of variable speed drives with outputs to 90 hp are presented in Bulletin G-5812. Condensed specifications, available speed variations, and construction features of Vari-Speed Motodrives, adjustable pitch motor pulleys, and variable speed transmissions are presented. 8 pages. Reeves Pulley Co., Columbus, Ind. J

Circle 661 on Page 19

Magnetic Contactors

"New Magnetic Contactors—Current and Horsepower Rated" is title of Bulletin 41-B2. They are rated through 10 hp, 220 v and 15 hp, 550 v polyphase, 20 to 40 amp, and with 2, 3, and 4 poles. 4 pages. Furnas Electric Co., 1045 McKee St., Batavia, Ill. I

Circle 662 on Page 19

Nylon Parts

Nylon components formed by cold pressing and sintering nylon powders are subject of bulletin "Nylasint." Porous type parts can be oil impregnated for wear resistance. 4 pages. Halex Corp., 26302 W. Seven Mile Rd., Detroit 40, Mich. H

Circle 663 on Page 19

Polyester Glass Laminates

Low-cost insulation sheets and fabricated parts of polyester glass base Dilecto and Celeron laminates for mechanical and electrical applications are subject of Bulletin PD-59. Properties are listed. 4 pages. Continental-Diamond Fibre Corp., Newark, Del. C

Circle 664 on Page 19

Steel & Alloy Castings

"1959 Reference Chart" tabulates mechanical properties, analyses, specification designations, and heat treatments recommended for carbon, low alloy, and stainless steel castings. General applications are listed for each material. 6 pages. Lebanon Steel Foundry, Lebanon, Pa. E

Circle 665 on Page 19

Automation Control Centers

Typical custom control centers for all types of automation systems and automatic machinery are detailed in bulletin entitled "Condeco." 4 pages. Control Design & Fabricate, Inc., 30725 Twelve Mile Rd., Farmington, Mich. H

Circle 666 on Page 19

Electronic Computer

Specifications, basic features, major components, and applications of the new LGP-30 general purpose computer are discussed in Bulletin S-526R1. Also shown is the optional photoelectric punched tape reader which handles 200 characters per second and the combination high speed reader and punch unit. 6 pages. Royal McBee Corp., Data Processing Div., Port Chester, N. Y. D

Circle 667 on Page 19

Power Supplies

How Magitran solid state power supplies combine advantages of transistor and magnetic regulators is explained in Catalog 114. Models are available for supplying regulated voltages up to 150 v dc and up to 20 amp. 4 pages. Electronic Research Associates, Inc., 67 Factory Pl., Cedar Grove, N. J. D

Circle 668 on Page 19

Vibration & Shock Controls

Bonded tube form mountings and Dynaflex Joints, engineered for vibration and shock control, are described in Bulletin 713. First isolate steady-state vibration and provide protection from infrequent shock and noise attenuation. Dynaflex Joints serve as pivot points to eliminate wear and lubrication, and they provide controlled flexibility between connected parts. 12 pages. Lord Mfg. Co., 1635 W. 12th St., Erie, Pa. F

Circle 669 on Page 19

Mill Motor Couplings

Design features, ratings, and operation of Fast's mill motor couplings are covered in Bulletin 1049. Self-aligning steel couplings for all tapered shaft ends are made in ¾ to 6⅝-in. shaft sizes. 4 pages. Koppers Co., Metal Products Div., 200 Scott St., Baltimore, Md. C

Circle 670 on Page 19

Tape Punch & Reader

Specifications and illustrations of the Model 28 tape punch and tape reader are found in two bulletins. Both have 100 word per minute capacity. Punch translates incoming sequential signals into perforations in tape, and the reader translates the perforated tape into electrical impulses for transmission. 4 pages each. Teletype Corp., 4100 Fullerton Ave., Chicago 39, Ill. J

Circle 671 on Page 19

Flow Rate Transmitter

The MPT motion position transmitter is detailed in illustrated Bulletin 170. Building block construction permits addition of an electric or pneumatic transmitter or an integrator, all of which are described. 12 pages. Brooks Rotameter Co., Box 432, Lansdale, Pa. E

Circle 672 on Page 19

BARKSDALE AIR-SEAL* VALVES

LOW PRESSURE AIR TO 250 P.S.I.

. . . over 200 different valves available.

Why so many different air valves?

Because air valve requirements vary with the method of actuation. A basic valve with interchangeable actuators cannot possibly meet ALL your specific applications without compromise. For example: A solenoid valve designed for speed would not have the stamina required of a manual or foot valve.

The Barksdale line of AIR-SEAL Valves has been designed with your requirements in mind. All our valves have been engineered for best performance from your point of view . . . for YOUR specific need, and not to make OUR job easier.

**The air pressure is the sealing force . . . the higher the pressure, the tighter the seal.*

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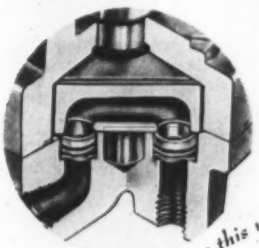


No oilers and filters needed — not critical to dirt and corrosion — made from non-corrosive materials.

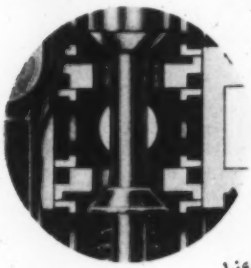
Years of leakproof service — without constant maintenance — Self aligning "Shear-Seal" design compensates for normal wear.

compare this with conventional SPOOL or PLATE VALVES

Alignment is critical — dirt and corrosion cause sticking.

There is no compensation for normal wear — leakage increases with use.

SOLENOID-PILOT CRESCENT® (Self-aligning poppet) VALVES



Quick response (12 milliseconds) due to short travel of poppets and solenoid.

Tight sealing — self-aligning, self-scavenging design adjusts to normal wear — not critical to dirt and corrosion — non-corrosive materials throughout.

No coil burnout — heat dissipating "integral" design.

compare this with conventional SPOOL VALVES

Slower response due to long spool travel.

Leakage increases with use — dirt and corrosion particles are ground-in between spool and seals—Sticking!

Overheating causes coil burnout — poor heat transfer of "unitized" design.

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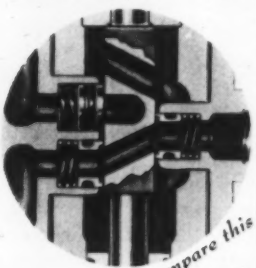

Leakproof for years of service — self-adjusting to wear.

No coil burnout — because valve does not freeze up.

compare this with conventional SPOOL VALVES

Dirt enters spool clearances — develops leaks — causes sticking — sticky valves are to blame for most solenoid burnout.

Write for Air Valve Catalog 9-AV

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Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

MANUALLY OPERATED

4-Way valves ¼ to 1½" N.P.T. with or without spring return

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4-Way valves ¼, ⅜ and ½" N.P.T. with or without spring return

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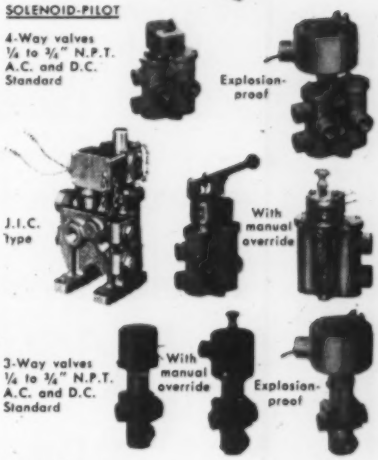

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With manual override

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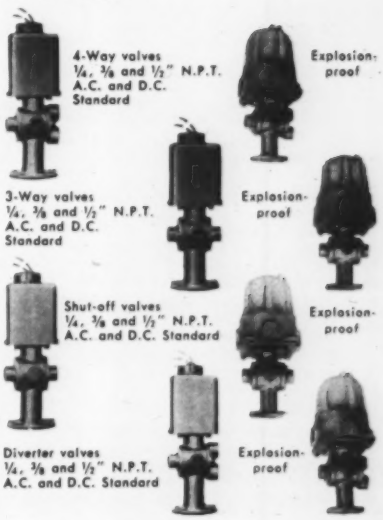

4-Way valves ¼, ⅜ and ½" N.P.T. A.C. and D.C. Standard

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Diverter valves ¼, ⅜ and ½" N.P.T. A.C. and D.C. Standard

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Circle 532 on Page 19

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. . . the best—Strom combines 40 years' experience with the most modern methods and machinery to produce the world's finest balls.
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Speed Reducers

Double reduction, hollow shaft, worm gear speed reducers in torque arm and flange mounted types are described in illustrated Catalog HSDR-58. Three sizes in each type cover a 0.041 to 2.552 hp output range, ratios from 66-2/3 to 4466:1, and maximum output torque from 1380 to 7678 lb-in. 12 pages. Winsmith, Inc., 6 Elton St., Springville (Erie County), N. Y. N

Circle 673 on Page 19

Company Capabilities

"Capabilities Illustrated" is a comprehensive illustrated booklet which describes the operations and products of this company. Among products are telephone distribution equipment, aircraft components, electronic systems, piping accessories, and many others. Research facilities are detailed. 96 pages. Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill. I

Circle 674 on Page 19

Air & Speed Couplings

Straight-through, single check valve, and double check valve types of Quick-Seal couplings for hydraulic and pneumatic applications are subject of illustrated Bulletin QSR 58. Various alloys and sizes are offered. Cross-sectional drawings are included. 20 pages. Titeflex, Inc., Hendee Street, Springfield 4, Mass. B

Circle 675 on Page 19

Glass-Reinforced Plastic

Technical data on Thermaflow 105 glass-reinforced polyester molding compound are included in folder. Physical, electrical, and chemical properties are given, along with recommended molding conditions. 4 pages. Atlas Powder Co., Chemicals Div., Wilmington 99, Del. C

Circle 676 on Page 19

Power Supply

Closely regulated output voltages of 150 v, 630 ma; 150 v, 100 ma; and 300 v, 40 ma are offered by the transistorized P/N 380-100 power supply. Its specifications are given in Data Sheet 380-100. 2 pages. Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif. L

Circle 677 on Page 19

Brazing Sheet

Engineering Data Sheet 4-A discusses 0.005-in. thick flexible Nicrobraz brazing sheet for high temperature honeycomb applications. Properties, application data, and advantages are covered. 1 page. Wall Colmonoy Corp., 19345 John R St., Detroit 3, Mich. H

Circle 678 on Page 19

Liquid Line Strainers

Pumps, meters, and other equipment can be protected against damage by dirt, scale, and rust in liquid lines by OPW strainers, described in illustrated Bulletin F-36. Offered in various sizes and types, they have woven Monel and brass screens. 4 pages. Jordan Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 679 on Page 19

Circle 533 on Page 19

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

HOW TO TAKE A SNAPSHOT OF A SATELLITE IN FLIGHT

If snapshooting satellites is on your agenda, contact either Boller & Chivens/-Joseph Nunn, South Pasadena, California, or the Perkin-Elmer Corporation, Norwalk, Connecticut.

In collaboration, these two firms make just what space photographers need. It's called the IGY Satellite Tracking Camera. And, of necessity, it's somewhat larger than the cameras most of you are accustomed to using. Like this.

Twelve of these cameras are now in use around the world. Each is designed to, first, take a picture when fixed on and following the *satellite*. This renders the subjects as a point against a background of streaks from the brightest stars. Then a second exposure is taken with the camera fixed on and moving with the *stars*. This provides the reference for determining the satellite's location.

And us? We provide the mirror blanks for Perkin-Elmer, who in turn handle the complete optical system. (The West Coast firm provides mechanical components and does the assembling.) The blanks we furnish are 31¾″ in diameter and 7″ thick. They are made from glass No. 7160, the very same glass used in casting the now-famous, 20-ton, 200″ disc for the Mt. Palomar Observatory.

The big advantage in using this particular glass is its very low linear coefficient of expansion—23 x 10^{-7} per ° C. Low expansion means a minimum of distortion, a much-appreciated contribution in the complex optics called for in taking pictures of satellites.

These king-sized mirrors lead us quite naturally to remind you that *Corning can do almost anything with glass*. Find out for yourself. Get a copy of "This Is Glass." Use the coupon for quick service.

NEW GIANT GLASS FLASK FOR THE IN-BETWEEN TASK

What intrigues the man in the picture is the *size* of the crystal clear vessel he is examining.

His interest is justified because as far as we know this is the *biggest* all-glass reaction flask on the market. It's new; it measures 18 inches in OD and stands 26 inches high. Capacity is 20 gallons.

We provide this size—along with 5 and 10-gallon versions—for people (maybe you) who need to fill the gap between lab and pilot plant.

You also can get all the trimmings. Like the five-opening all-glass cover that's visible behind the flask. Such covers can be had with pipe flanges, ⅁, or socket joints. Accessories include inlet tubes, condensers, blind caps, clamps and thermometer wells. Need one? Just write for details.

This outsized glassware is all made from PYREX brand glass No. 7740—a glass that performs admirably because of the virtues detailed elsewhere on this page.

Which brings us to this diminutive and relatively intricate container known as a Warburg flask. It's quite commonplace to biochemists who use it for measurement of cell respiration and tissue metabolism. It's also a stock item with us.

We call the big ones and the little ones *both* to your attention because it points up the fact that size or shape is a consideration—*not* a limitation—to the skilled glassworkers at Corning.

Investigate by tossing us any one of your tough problems. We'll look for a glass answer and let you know soon what we can do.

PLUMBING FOR POSTERITY

An increasingly popular fixture in labs, hospitals, schools, chem plants, and photoengraving shops is the glass drainline.

With good reason. Glass drainlines are fashioned from PYREX brand glass No. 7740.

This is the glass that ends your worries about corrosion. For example, if you were disposing of waste hot hydrochloric acid, your PYREX pipe would still be around at the end of 200 years.

And glass is smooth; very little chance for block-up in the pipe. If such does occur, however, you can spot the exact point and take corrective action, without having to take down the whole system.

In fact, almost anything made from PYREX brand glass No. 7740 will be around for quite a while because this glass is able to cope with thermal shock and physical knocks, too.

Available in many forms—tubing, rod, pipe, plate, and all kinds of shapes.

Fill in the gaps in your files with these basic references: PE-30, all about glass drainlines; IZ-1, design considerations in glass. Any or all, free. Use the coupon.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 52 Crystal Street, Corning, N.Y.

Please send me: ☐ "This Is Glass"; ☐ Drainline Manual, PE-30; ☐ Design Manual IZ-1; ☐ Info on Reaction Flasks

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

Circle 534 on Page 19

NEW SOLENOID VALVES *by* Airmatic

These corrosion-proof valves have only one internal moving part and a completely protected solenoid coil. The coil is fully sealed from air, oil, gas and water . . . and will not overheat on continuous duty. Coils for continuous or intermittent duty, a-c or d-c, are interchangeable.

Life expectancy is many millions of cycles and by renewing the one-piece valve plunger, many millions more can be expected. The plunger can be replaced without disturbing rigid piping.

DISTRIBUTORSHIPS FOR THESE NEW VALVES ARE AVAILABLE

SPECIFICATIONS		
	TWO-WAY	**THREE-WAY**
CATALOG NO.	91011	91011
PRESSURE RANGE	1/16" ORIFICE: 0-500 PSI 3/16" ORIFICE: 0- 70 PSI	1/8" ORIFICE: 0-300 PSI 3/16" ORIFICE: 0-100 PSI
ORIFICES	1/16" THROUGH 3/16"	1/8" AND 3/16"
VOLTAGE	MOST A-C AND D-C	MOST A-C AND D-C
DUTY	CONTINUOUS	CONTINUOUS
POWER CONSUMPTION	10 - 20 WATTS	10 - 20 WATTS
HEAT RISE	WITHIN UL LIMITS	WITHIN UL LIMITS

OPTIONAL DESIGNS

MANUAL OVER-RIDE

MANIFOLD MOUNTING

ASK FOR CATALOG

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7313 Associate Avenue • Cleveland 9, Ohio

EVERYTHING UNDER CONTROL

Phone: WOodbine 1-5320 • WESTERN UNION: Airmatic Valve, Inc., FAX, Cleveland, Ohio

Circle 535 on Page 19

Hose Couplings & Fittings

Wide variety of Le-Hi hose couplings and fittings for many types of industrial rubber hose are described in illustrated Condensed Catalog 34. Valves and manifolds, hose clamps, and reusable hydraulic couplings are among the products noted. 8 pages. Hose Accessories Co., 2704 N. 17th St., Philadelphia 32, Pa. E

Circle 680 on Page 19

Strain Gages

Over 250 types of SR-4 strain gages, instruments, and accessories are detailed in Specification and Price List 4310. Electrical and physical specifications of each gage type are included, as is selection information. Strain gage instruments and kits are also covered. 24 pages. Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham, Mass. B

Circle 681 on Page 19

Solenoid Valves

Pilot operated B-type single and double solenoid control valves are subject of Bulletin 582-A. They have ½-in. flow or 257 cfm at 100 psi. Design features and specifications are given. 4 pages. Hunt Valve Co., Salem, Ohio. G

Circle 682 on Page 19

Centrifugal Switches

Adjustable speed range from 70 to 5000 rpm is a feature of the Type C centrifugal switch, subject of illustrated Bulletin 2210. Application data, cutaway views, and operating features are given. 4 pages. Euclid Electric & Mfg. Co., Madison, Ohio. F

Circle 683 on Page 19

Electromagnetic Clutch

Design features, operating data, table of dimensions, and technical rating data on the electromagnetic tooth clutch are found in illustrated Bulletin 358. Unit engages up to 300 rpm relative speed and has no idle torque. 4 pages. McCauley Industrial Corp., 1840 Howell Ave., Dayton 17, Ohio. G

Circle 684 on Page 19

Motor Controls

Product pictures, wiring diagrams, dimensional drawings, and prices for extensive line of motor controls are found in Reference Catalog 14. Size, weight, and ratings are given for various types of starters, relays, pushbuttons and stations, and other controls and accessories. Specifications are included for all units. 80 pages. Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn. B

Circle 685 on Page 19

Steam Heaters

Instantaneous heaters with extra-large steam inlet area are subject of illustrated Bulletin 304.4K1. Selection tables, charts, and piping diagrams are included, along with selection information and design features. 24 pages. American-Standard, Industrial Div., Detroit 32, Mich. H

Circle 686 on Page 19

AIRCRAFT · MISSILES · ROCKETS · AUTOMOTIVE · COMPRESSORS
DIESELS · ELECTRICAL MACHINERY · PROCESSING MACHINERY
CONSTRUCTION EQUIPMENT · COMPUTING MACHINES · PUMPS
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Smart Designers Everywhere
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how to save Assembly Dollars with the big
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... and NO dirt between layers, ever! ... by specifying LAMINUM

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the solid Shim that p-e-e-l-s for adjustment
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STAINLESS STEEL	ALUMINUM	BRASS	MILD STEEL
with laminations of .002" or .003"	with laminations of .003" or NEW .002"	with laminations of .002" or .003"	with laminations of .002" or .003"

LAMINATED SHIM COMPANY, INC.
EAST COAST Home Office and Plant
1203 Union St., Glenbrook, Conn.
WEST COAST Sales Office
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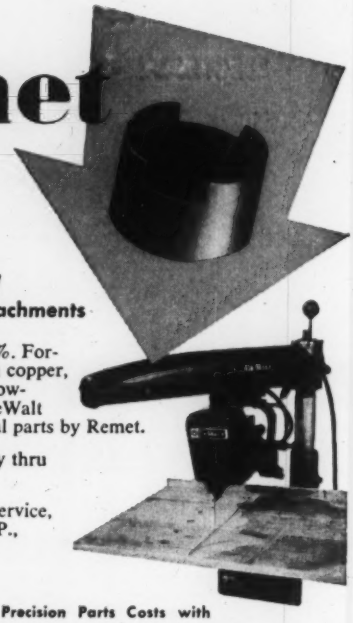
Circle 536 on Page 19

11 Remet POWDERED METAL PARTS

now go into DEWALT POWER SAW and attachments



- This Remet collar reduced part cost 80%. Formerly a precision casting in beryllium copper, it is now a Remet copper infiltrated powdered iron part. Advantages led to DeWalt specifying 11 different powdered metal parts by Remet.
- DeWalt now offers greater saw accuracy thru maintenance of closer tolerances.
- "You can depend on Remet for better service, fast delivery," states A. C. Wedge, V.P., Mfg., DeWalt Div., American Machine & Foundry Company.

FREE, NEW BROCHURE "How to Cut Precision Parts Costs with the Remet Powdered Metal Process" gives complete information. Send for your copy today.

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REESE METAL PRODUCTS CORPORATION
537 Howard Ave., Lancaster 11, Penna.

Gears • Pinions • Cams • Ratchets "Oilless" Bearings • Bushings • Machine and Structural Parts in COPPER • BRASS • IRON • ALLOY STEEL • NICKEL SILVER • COPPER INFILTRATED IRON

Circle 537 on Page 19

ATTACHMENT and FASTENING

PROBLEM SOLVER

Applied with standard TRS riveting machines

Solve design problems with PERMA-NUTS and get the speed and economy in production that goes with automatic feeding and setting of standard tubular rivets. An important advantage of this unique combination nut and rivet! A built-in "lock washer" feature is another.

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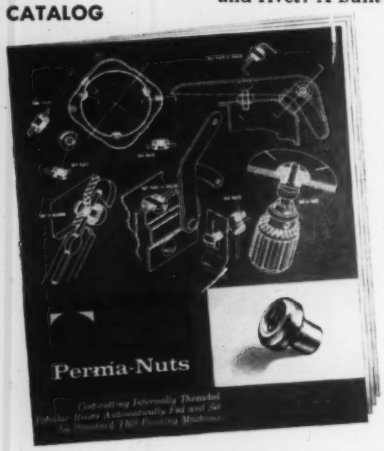
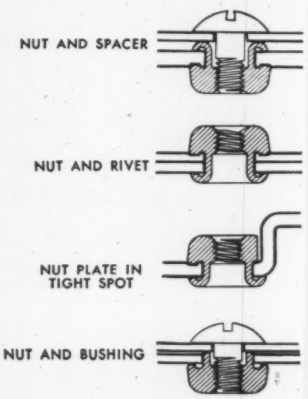




TUBULAR RIVET & STUD CO., *Quincy 70, Mass.*

Circle 538 on Page 19

HELPFUL LITERATURE

Permanent Magnets

"Magnetic Ideas from Eriez" is an illustrated folder which describes many uses for Eriez permanent plate magnets, grate magnets, magnetic humps, magnetic pulleys and drums, ferrous traps, Magna-Rails, Magna-Rolls, sheet fanners, vibratory feeders, and other permanent magnetic equipment. 48 pages. Eriez Mfg. Co., Erie 6, Pa. F

Circle 687 on Page 19

Adjustable Speed Drives

Operation and application of wide range, adjustable diameter, wedge belt sheaves is discussed in illustrated Catalog WRB-58. Installation and mounting dimensions are listed for both adjustable diameter and companion sheaves. Auxiliary equipment is also covered. 4 pages. American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa. E

Circle 688 on Page 19

Flow Control Valves

Two illustrated Bulletins VFC-3 and 143-A present application data, specifications, optional features, and engineering drawings of a line of multirange flow control valves. They are made in ¼, ⅜, and ¾-in. sizes and are rated 3000 psi. 6 and 4 pages. American Brake Shoe Co., Denison Engineering Div., Columbus 16, Ohio. G

Circle 689 on Page 19

Rectifiers & Diodes

Ratings, electrical characteristics, and descriptive data on 405 types of silicon and selenium rectifiers and diodes are found in illustrated short form Catalog 14. 16 pages. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif. L

Circle 690 on Page 19

AC Motors

Concise selection data on 1 to 200-hp alternating current motors are content of motor selector Bulletin B-2103-4. Brief explanations of NEMA design classes, speed-frequency relationship, current and torque values, and frame selection tables are included. 12 pages. Reliance Electric & Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio. F

Circle 691 on Page 19

Stainless Steel

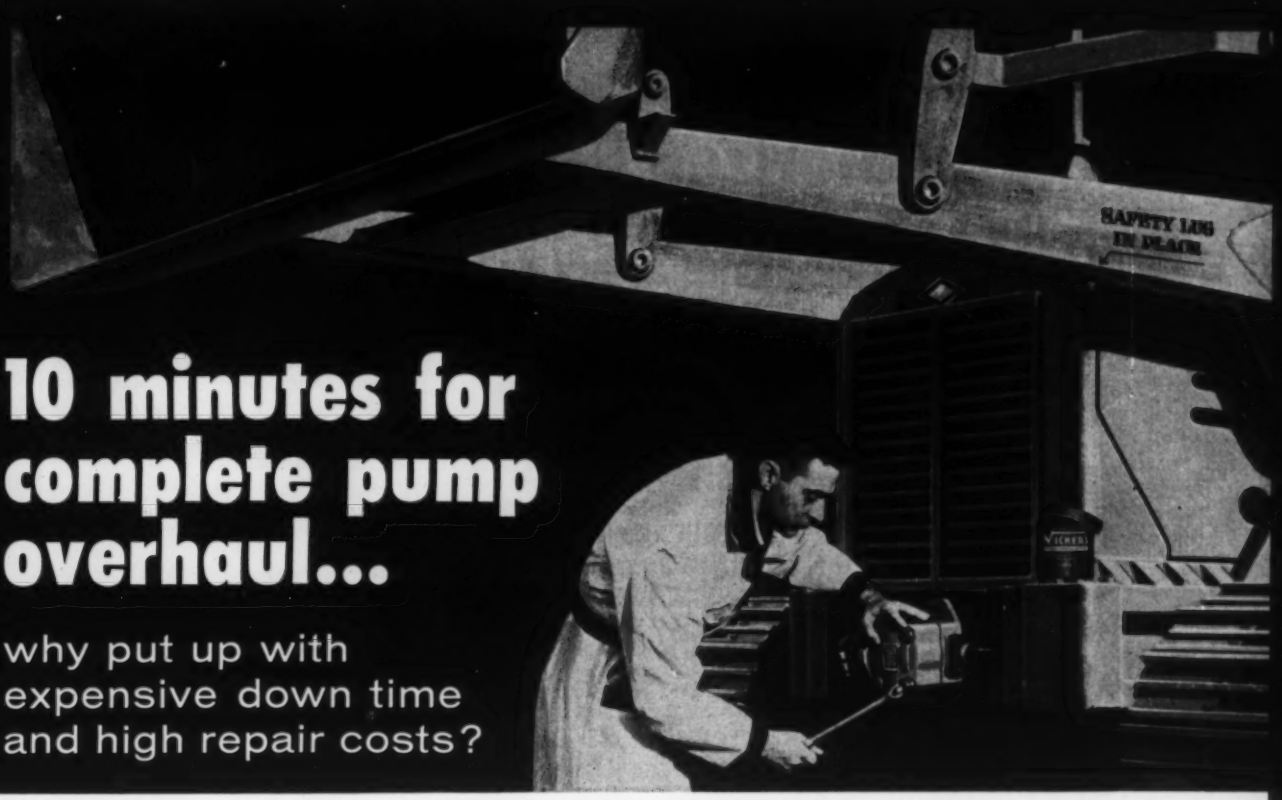
New grades and finishes of stainless steel are covered in bulletin "Here's What's New in Armco Stainless Steel." Available grades and the many forms available are listed. 6 pages. Armco Steel Corp., 5758 Curtis St., Middletown, Ohio. G

Circle 692 on Page 19

Ductile Iron

Line of ductile iron products catalogued in Brochure L-127 includes pipe, tubing, casing, fittings, and special castings. Technical data cover grades, specs, dimensions, uses, and applications. Available pipe diameters range from 2 to 48 in. 36 pages. American Cast Iron Pipe Co., Box 2603, Birmingham 2, Ala. A

Circle 693 on Page 19



10 minutes for complete pump overhaul...

why put up with expensive down time and high repair costs?

on the spot maintenance with

VICKERS®

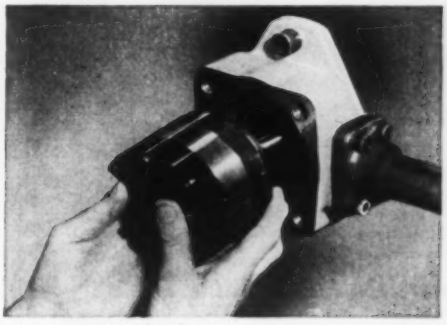
"High Performance" Pumps*
keeps your jobs on schedule
*PATS. & PATS. PENDING

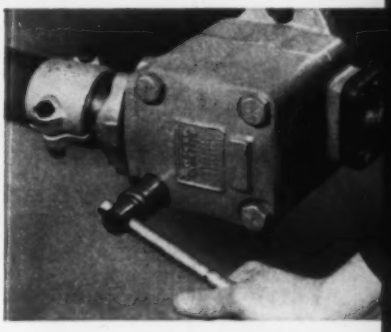
Without removing the pump from the vehicle, and without disconnecting hydraulic lines, the new Vickers "High Performance" pump can be completely overhauled by simply inserting a new pumping cartridge. The pumping cartridge contains all wearing parts in one replaceable unit and results in new pump performance. Write for Bulletin No. M5108 for performance characteristics.

1. After safety, cleanliness and draining instructions have been followed per vehicle manufacturer's recommendations, take out four cover bolts and remove cover.

2. Take out old pump cartridge and insert new one. The cartridge includes cam ring, rotor, vanes, etc. —all parts in one assembly.

3. Replace cover and you have the equivalent of a new pump ready for long, trouble-free service.





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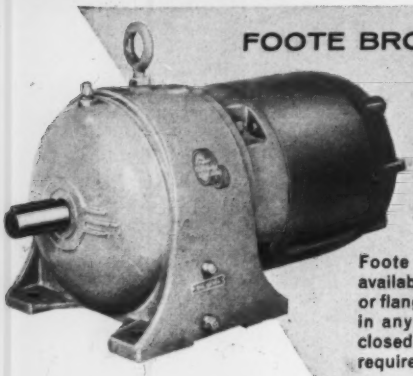
Circle 539 on Page 19

FOOTE BROS. **Motorized Drives**

Duti-Rated LIFETIME GEARING

Gives You More Power Per Dollar



FOOTE BROS.-LOUIS ALLIS

GEARMOTORS

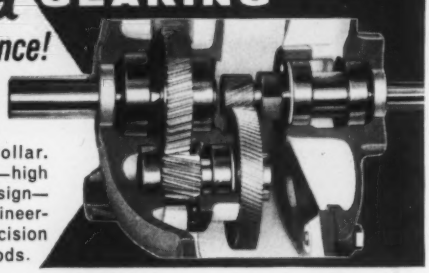
1 to 150 HP...Single, Double, Triple, Quadruple Reductions . . . Output Speeds from 780 to 7.5 RPM

Foote Bros.-Louis Allis Gearmotors are available in over 3500 types and sizes. Foot or flange mountings. Motors can be ordered in any type—open drip-proof, totally enclosed, explosion proof, etc. to meet your requirements.

Duti-Rated GEARING

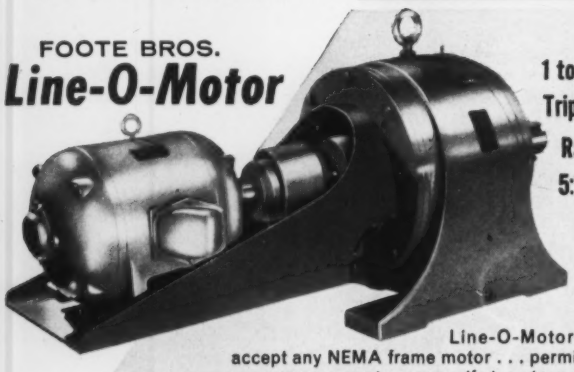
Makes the Difference!

Duti-Rated Gearing is the heart of Foote Bros. Motorized Drives . . . drives that give you more load capacity and wear life per dollar. This is premium quality gearing—high hardness, accurate, balanced design—the product of thousands of engineering and development hours, precision tooling and manufacturing methods.



FOOTE BROS.

Line-O-Motor



1 to 75 HP...Double, Triple Reductions...

Ratios:

5:1 thru 238:1

Line-O-Motor Drives accept any NEMA frame motor . . . permit you to use your own motor or specify type to meet plant standardization. Foot or flange mounted.

Write for CATALOG MRA. It has complete details and selection data on Foote Bros. Motorized Drives.

100 YEARS SERVING INDUSTRY 1859-1959

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION

4567 SOUTH WESTERN BOULEVARD • CHICAGO 9, ILLINOIS

V-Belt Drives

Construction features of Dyna-V sheaves and V-belts which enable them to deliver up to three times as much horsepower in a given space are pointed up in Bulletin A-695. Sheaves, available in two standard groove sizes, cover all except the largest industrial requirements. Made-to-order units handle up to 1500 hp. 44 pages. Dodge Mfg. Corp., Mishawaka, Ind. J

Circle 694 on Page 19

Nickel Base Alloy

Hastelloy alloy F, a nickel base alloy, resists oxidizing and reducing conditions and stress corrosion cracking. Its physical, chemical, and mechanical properties are listed in Booklet F-30,128. 12 pages. Haynes Stellite Co., Kokomo, Ind. C

Circle 695 on Page 19

Forging Facilities

The scope of forging development as practiced by this company is revealed in brochure "Cameron Forging." High density alloy and stainless steels are forged into jet engine and nuclear reactor components by this company and range in weight from a few pounds to several thousand pounds. 40 pages. Cameron Iron Works, Inc., Special Products Div., Box 1212, Houston 1, Tex. P

Circle 696 on Page 19

Vinyl Products

Illustrated brochure briefly describes design facilities, die making, compounding, process control, and extrusion as related to the production of industrial vinyl products. 16 pages. Industrial Vinyls, Inc., 5511 N.W. 37th Ave., Miami, Fla. O

Circle 697 on Page 19

Aluminum Casting Alloy

Specifications, properties, and performance data on A356 high purity aluminum casting alloy ingots are contained in Form PI-801. Uses include aircraft and missile components, cylinder blocks, pressure vessels, hydraulic pressure fittings, and machine tool equipment. 8 pages. Kaiser Aluminum & Chemical Sales, Inc., Dept. NR-24, 919 N. Michigan Ave., Chicago, Ill. M

Circle 698 on Page 19

Abrasion Resistant Materials

"The Role of Molybdenum in Abrasion Resistant Materials" is described in brochure of this title. It covers materials which resist gouging, grinding, and scratching. Proper selection of materials for particular conditions of wear is covered. 36 pages. Climax Molybdenum Co., 500 Fifth Ave., New York 36, N. Y. D

Circle 699 on Page 19

Gearmotors

Information on 1/3 to 30 hp, single reduction gearmotors with output speeds of 23 to 280 rpm is provided by Bulletin 3050. In these units, motor and worm gear reducer are combined integrally. 4 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 700 on Page 19

Making Repair Parts

Booklet on "How to Make Your Own Machine and Repair Parts Quicker and Easier" covers care and trouble-shooting of machines and equipment, machining, and welding techniques. It contains drill hole tolerances and a grinding limits chart. 24 pages. La Salle Steel Co., Box 6800-A, Chicago 80, Ill. J

Circle 701 on Page 19

Vacuum Castings

Company has begun production of investment castings using the latest vacuum metallurgy which assures complete removal of atmospheric gases and vapors, virtual elimination of blowholes, and inclusions. Brochure describes the facilities. 4 pages. Sigourney Mfg. Corp., South Acton, Mass. B

Circle 702 on Page 19

Converter-Inverters

The Transidyne line of transistorized converter-inverters is subject of Data File 701. It pictures various case styles and lists features and specifications of four basic series. 4 pages. Spectrol Electronics Corp., 1704 S. Del Mar Ave., San Gabriel, Calif. M

Circle 703 on Page 19

Electric Actuator

On-off or throttling control of valves, dampers, louvers, metering pumps, and speed changers are typical uses for the Model D-62XW electric actuator described in Bulletin D-62-1. It has choice of ½ to 4-in. travel at speeds from 2½ to 8½ ipm for loads from 100 to 700 lb. 2 pages. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa. E

Circle 704 on Page 19

Synchronous Generators

Ratings up to 187 kva in single or three phase types are available in line of nonpackaged synchronous generators which are subject of Publication 2100-PRD-254. Construction features are shown. 2 pages. Electric Machinery Mfg. Co., Minneapolis 13, Minn. J

Circle 705 on Page 19

Production Facilities

How the teamwork of the research, engineering, and manufacturing departments of this company provides a unified facility for military and industrial systems production is explained in well-illustrated brochure. The functions of all three departments are detailed, and typical products are shown. 24 pages. General Mills, Inc., 1620 Central Ave. N.E., Minneapolis 13, Minn. J

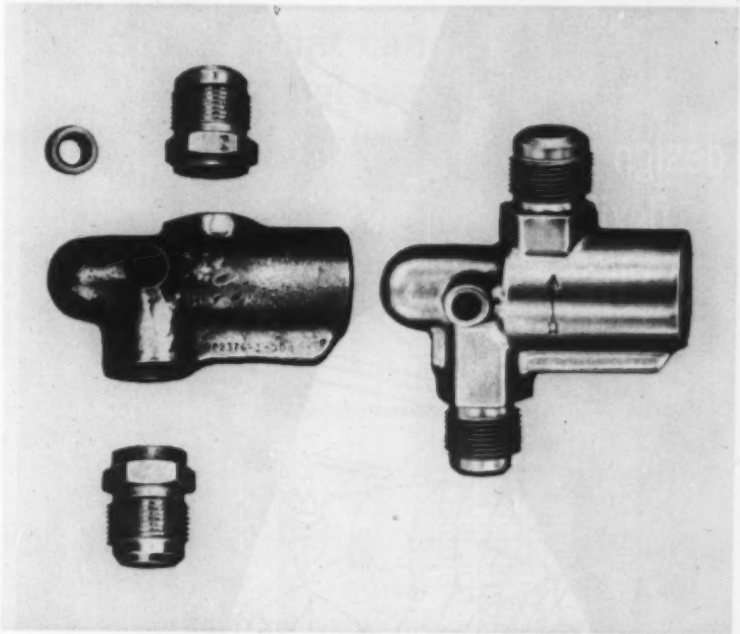
Circle 706 on Page 19

Adjustable Speed Drives

The basic methods of operating direct current motors from alternating current sources are detailed in Catalog 11058. Various types of equipment made by Servo-Tek for variable speed drive applications are described, and ratings are given. 16 pages. Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N. J. D

Circle 707 on Page 19

FOUR PARTS REDUCED TO ONE
—A BRIDGEPORT CORED FORGING STORY



The one-stroke Bridgeport cored forging on the right replaced the four-part casting assembly on the left.

The purpose of these valves is to control liquid under pressure. The four-part assembly shown on the right did not operate to fullest efficiency. Leakage frequently was present because of the porosity in the part's cast element.

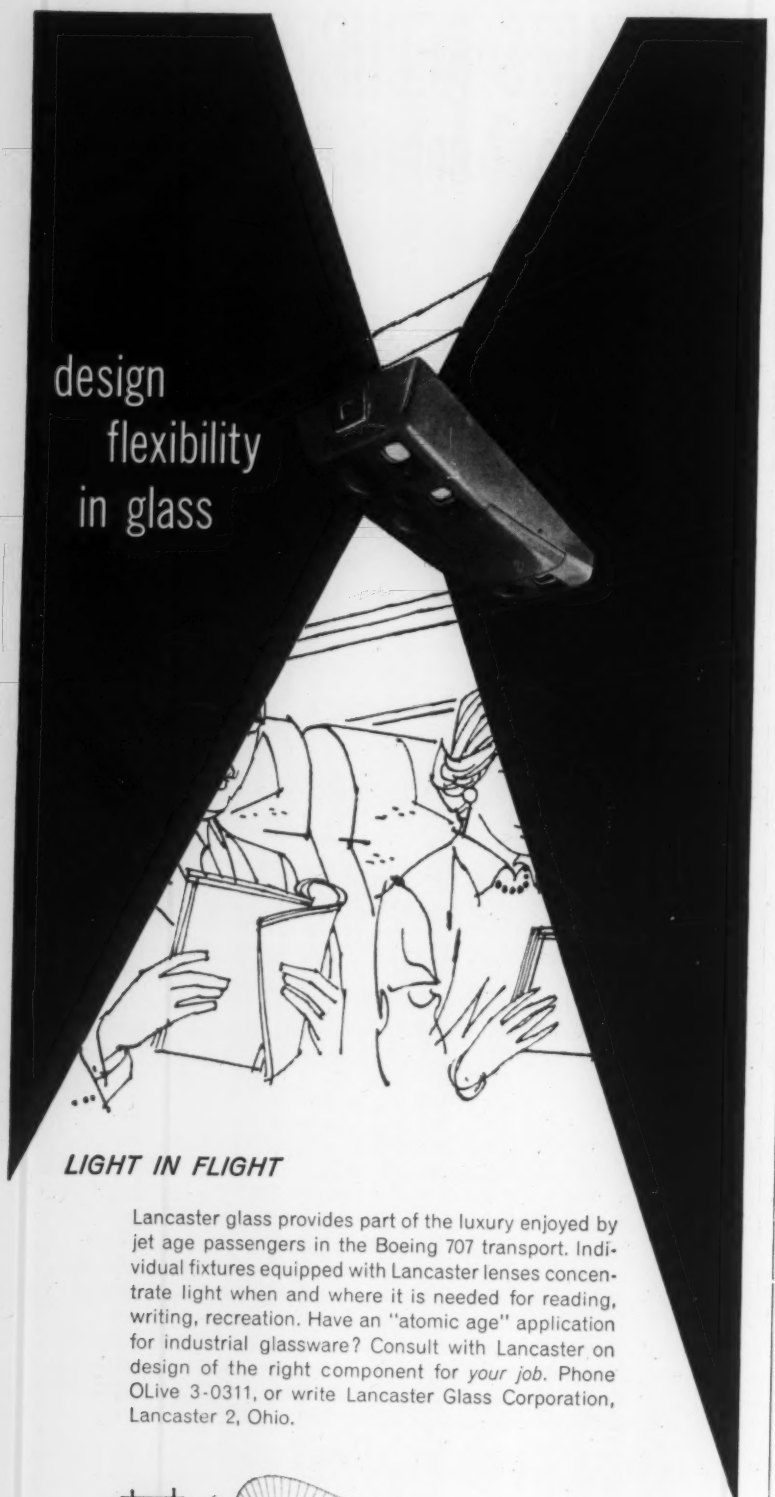
The Engineering Staff at Bridgeport's Cored Forging Division designed the economical one-piece cored forging pictured on the right to abolish – once and for all – the leakage problem as well as many of the production steps.

The control valve is now all one unit. Assembly time has been eliminated and inspection time and part porosity are things of the past. Good, positive chucking for threading operations has reduced machining time to the necessary minimum. This simple, yet significant achievement, is an example of what Bridgeport's forging processes, both die and cored, can do for your component or part. Learn more about Bridgeport's forging facilities.

Write to Dept. 8901 for your copy of our detailed 16-page brochure, "Bridgeport Forgings."

CORED FORGING DIVISION
BRIDGEPORT BRASS COMPANY
1000 Connecticut Ave., So. Norwalk, Conn.
Specialists in Metals from Aluminum to Zirconium

Circle 541 on Page 19



LIGHT IN FLIGHT

Lancaster glass provides part of the luxury enjoyed by jet age passengers in the Boeing 707 transport. Individual fixtures equipped with Lancaster lenses concentrate light when and where it is needed for reading, writing, recreation. Have an "atomic age" application for industrial glassware? Consult with Lancaster on design of the right component for *your job*. Phone OLive 3-0311, or write Lancaster Glass Corporation, Lancaster 2, Ohio.

Lancaster® glass
to brighten your product's future

Circle 542 on Page 19

Positioning Switches

Design and application information on positioning switches which gradually increase or decrease the flow of compressed air to controlling valves or motors is presented in Bulletin 357-3. 8 pages. Powers Regulator Co., Skokie, Ill. I

Circle 708 on Page 19

Gasoline Engines

Three 4-cylinder L-head gasoline engines with ratings from 28.4 to 46.5 hp are described in Bulletins E-128, E-129, and E-130. Specifications and performance data are included. 2 pages each. Hercules Motors Corp., Canton, Ohio. G

Circle 709 on Page 19

Glass Fabricating

Holding internal diameters to tolerances of ±0.0001 in. and better in production quantities is possible in glass fabricating. The technique and its applications are explained in illustrated Catalog 80-23. Any type of glass can be precision fabricated into diverse equipment. 8 pages. Fischer & Porter Co., Glass Products Div., Hatboro, Pa. E

Circle 710 on Page 19

Motors & Blowers

Standard subfractional horsepower motors and blowers are subject of illustrated Catalog 6-59. Capacitor, universal, two and four-pole induction, and gearmotors are detailed, as are single and double blowers and blower heaters. Specifications of all units are given. 16 pages. Heinze Electric Co., 685 Lawrence St., Lowell, Mass. B

Circle 711 on Page 19

Treated Felts

Two-inch square samples of five new and seven other treated felts are contained in a sample folder. New types are WesTemp for high temperature, Teflon coated for reducing friction, and thermoplastic resin impregnated, Mylar coated, and polyethylene film coated for abrasion resistance. Others are for lubricant seals, padding under machinery, resisting weather, reducing friction, and repelling water. Western Felt Works. Dept. L, 4021 W. Ogden Ave., Chicago 23, Ill. I

Circle 712 on Page 19

Switches

Type 210 instrument and control switches for use in circuit breakers, motor-operated rheostats, and other electrically controlled apparatus are subject of illustrated Bulletin 14B8112B. Construction features are given for the units, rated for 20 amp continuous capacity with 600-v insulation. 4 pages. Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. K

Circle 713 on Page 19

Flexible Couplings

Series 400 four-pin flexible couplings for connecting motors directly to pumps, fans, speed reducers, etc., are described on Catalog Sheet 67. Sizes covered handle 1.2 to 6.42 hp per 100 rpm. 2 pages. Ajax Flexible Coupling Co., Westfield, N. Y. F

Circle 714 on Page 19

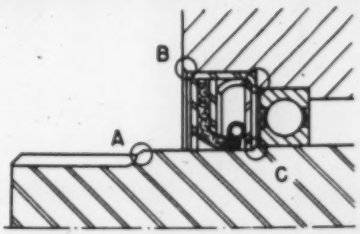
NATIONAL® OIL SEAL LOGBOOK

4 common shaft sealing conditions

. . . and engineering tips that can help you "design-in" better oil seal performance

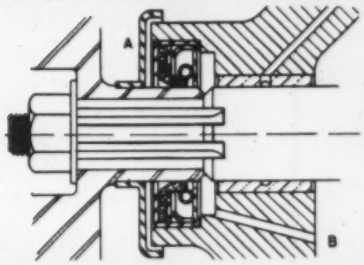
CONVENTIONAL INSTALLATION

Here a standard-design single lip seal retains lubricant and excludes normal dirt, dust and moisture. Sealing lip points in since seal's principal job is retaining oil or grease around bearing. Note that shaft is stepped and chamfered at "A" to prevent damage to sealing lip during installation. At "B", bore is chamfered to facilitate seal entry. At "C", counterboring insures accurate positioning of the seal.



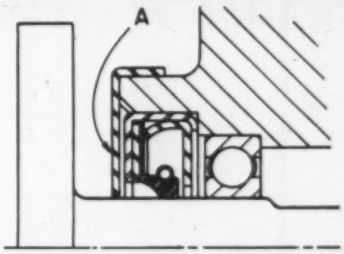
HEAVY DIRT CONDITIONS

Here is a commonly used method of protecting the seal and increasing seal life on applications subjected to extreme dirt conditions. The guard baffle at "A" is welded or swaged to the wheel hub to exclude the major portion of dirt and dust. The drain hole at "B" relieves pressure at the sealing point. In addition to the guard baffle, many manufacturers employ a dual-lip seal to insure bearing protection under extreme dirt conditions.



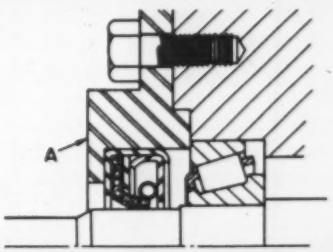
SEALING LONG, HEAVY SHAFT

Many cases of so-called "seal failure" are due solely to poor installation techniques. While today's seals are rugged, they can be rendered non-serviceable if distorted out of round, cocked in the bore, or if the sealing lip is torn. To protect the seal against such physical damage during installation involving a long shaft, a seal protector as shown at "A" may be mounted on the hub O.D.



INSUFFICIENT DEPTH TO MOUNT SEAL

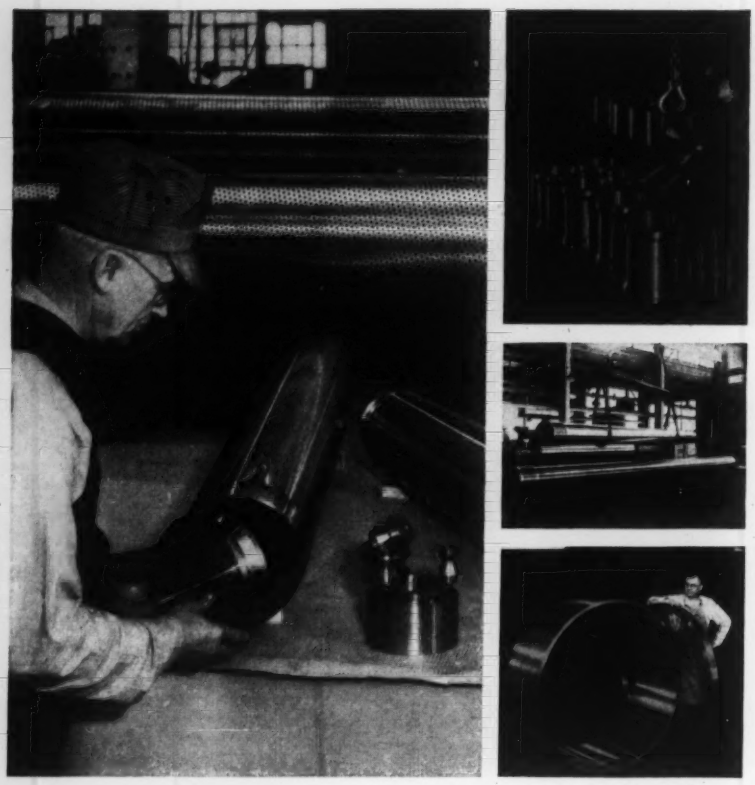
Where the housing does not provide sufficient depth for counterboring, or where seal installation would be difficult or likely to damage the seal, a separate mounting member ("A") can be employed. As before, the shaft should be chamfered to prevent damage to the sealing lip during installation.



NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California
Van Wert, Ohio

5207

Circle 543 on Page 19



Your parts last longer when they're

SHENANGO CENTRIFUGAL CASTINGS

Your machine parts, ferrous or non-ferrous, are subject to stress, strain and friction, day after day, year after year . . . so specify Shenango . . . and see what a difference this makes!

Shenango's centrifugal casting process insures longer life because of finer, more uniform, *pressure-dense* grain to begin with . . . free of inclusions, porosity, blowholes and other weakening defects. Then, far less machining is needed and your part is stronger . . . to last and last *and last!*

Shenango's modern and fully-equipped shops will supply you with ferrous or non-ferrous symmetrical parts in virtually any shape or size . . . rough, semi-machined or precision-finished to your most exacting specifications. For full details, write: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, Ohio.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

Circle 544 on Page 19

Cold-Drawn Tubing

Bulletin 41 is a selection and application guide for small-diameter tubing available in a wide range of sizes and metals and alloys. Characteristics are given on 63 standard and 26 special materials offered as small tubing. Special types covered include Hypoflex needle tubing for pressures up to 100,000 psi. 12 pages. Superior Tube Co., Norristown, Pa. E

Circle 715 on Page 19

Light Dimming Ballast

Design and application data on the new fluorescent dimming ballast for use with fluorescent luminaires are given in bulletin. Range of illumination from maximum to minimum is 500 to 1. 2 pages. Superior Electric Co., Bristol, Conn. B

Circle 716 on Page 19

Oscillating Conveyors

Three types of oscillating conveyors which can handle from 25 to 350 tons of material per hour are described in Book 2744. Operating principle and design details of these motor driven machines are covered. They will handle granular free-flowing materials as well as hot, abrasive, fine, dusty, and other hard-to-handle materials. 24 pages. Link-Belt Co., Prudential Plaza, Chicago 1, Ill. J

Circle 717 on Page 19

Vibration Mountings

Five basic vibration mounting methods discussed in illustrated Bulletin IND-11 are positive and negative isolation and steel spring, rubber-in-shear, and pad type mountings. Selection guide is included. 4 pages. Vibration Mountings, Inc., 98-15 50th Ave., Corona, L. I., N. Y. D

Circle 718 on Page 19

Machining of Aluminum

Data on machining practices, tool angles and designs, and tool materials are provided in handbook "Machining Aluminum." Proper speeds, feeds, lubricants, and cutting compounds are explained. Eight charts cover major machining operations. 32 pages. Request on company letterhead from Reynolds Metals Co., Box 2346, Richmond 18, Va. C

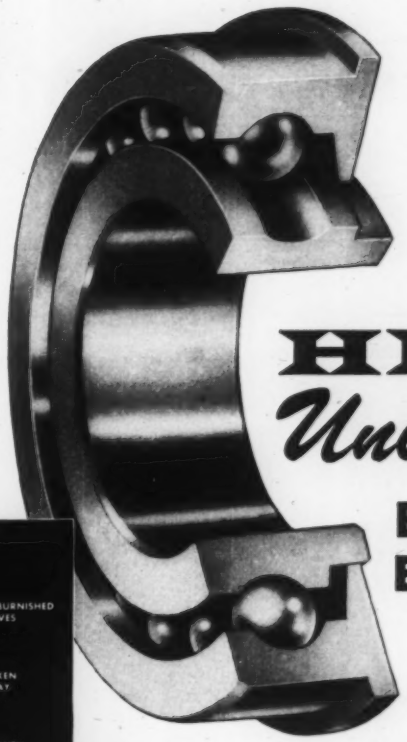
Nozzles

Wide variety of types of nozzles for industrial spraying applications is described in illustrated Catalog 59. Spray angles, dimensions, types of connections, and capacity vs. pressure data are presented. 32 pages. Request on company letterhead from Wm. Steinen Mfg. Co., Industrial Nozzle Div., 45 Bruen St., Newark 5, N. J. D

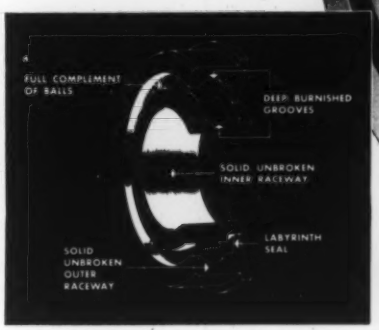
Aluminum Extrusions

Tables of physical and mechanical properties, tolerances, manufacturing limits, and fabricating characteristics are contained in spiral-bound booklet X1057 on aluminum extrusions. Technical data on variety of extrusion profiles are presented, along with other information. 92 pages. Request on company letterhead from Michael Flynn Mfg. Co., 700 E. Godfrey Ave., Philadelphia 24, Pa. E

a low cost ball bearing of superior quality and greater durability



HEIM *Unibal*® BALL BEARINGS



Note this unusual construction. There is no other ball bearing like it!

Suitable for requirements ranging from the commercial field to many precision applications heretofore using conventional ground ball bearings.

Its simplified construction and unusual assembly method produce a bearing which has no loading slots, no split raceways, and no inserts . . . yet there is a full complement of balls for smooth operation and optimum bearing life.

Deep, unbroken, burnished ball grooves. with closer tolerances and improved finish, provide maximum capacity for radial and thrust loads.

Unibal Ball Bearings can be furnished in single row, double row, flanged or snap ring types in a wide range of widths and diameters . . . even down to extremely narrow widths.

Where closed type bearings are required, shields, mechanical or close, integral labyrinth seals on one or both sides are available.

Our Engineering Department will be happy to help you select the correct bearing for your application. Write for UBB folder showing dimensions, load capacities at various rpm.

manufactured by THE HEIM COMPANY
for Universal Bearing Corporation
P.O. BOX 486, FAIRFIELD, CONNECTICUT

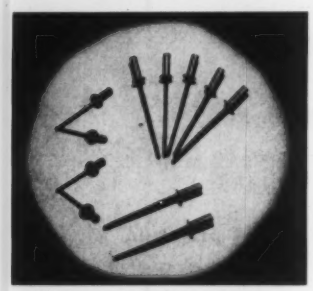
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Blind Rivet

sets and seals in one operation

Imex rivet is air and watertight at pressures as high as 500 psi, and is highly resistant to vibration. Rivet is set by pulling a mandrel into rivet shank, spreading and setting it. Radial expansion of shank is balanced with shear-strength criteria to ensure tightness under excessive vibration. Head of mandrel is encased within rivet and seats tightly against a shoulder formed during setting operation. Rivet is made with a short and



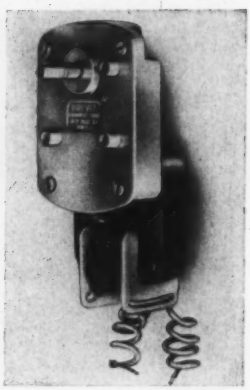
long-break mandrel, both with similar sealing characteristics. When rivet is fully set, short-break mandrel breaks off directly under blind head. When rivet with long-break mandrel is fully set, mandrel breaks at a point beyond work and acts as a steel core to reinforce entire length of rivet. Rivet is available in 0.125 and 0.187 in. diam in aluminum. **Pop Rivet Div., United Shoe Machinery Corp.**, West Medway, Mass. B

Circle 719 on Page 19

Fractional-Horsepower Motors

for slow-speed use

F series motors, for use where resistance to heat and splashing grease is important, incorporate heatproof, splashproof, and shatterproof housings. The slow-speed



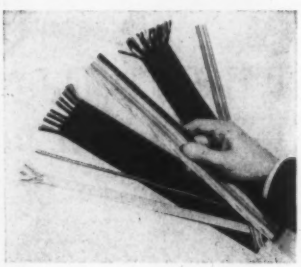
units provide long motor life and troublefree operation. **Brevel Products Corp.**, 601 W. 26th St., New York 1, N. Y. D

Circle 720 on Page 19

Ribbon Cable

for use where space is limited

Turbo ribbon cable is a flat multiconductor type which can be assembled from single conductors, twisted and jacketed pairs and triples, coaxial cables, shielded and jacketed wires, or any combination of these. Designed for specific applications to specifications, cable is available in 14 solid colors and striped wires. Conductor sizes are No. 28 to No. 8 AWG, strand or solid. Insulation is vinyl with or without extruded nylon jacket. Diameter over insulation is 0.034 to 0.250 in., and voltage rating is 300 to 3000 v rms. Cables are manu-



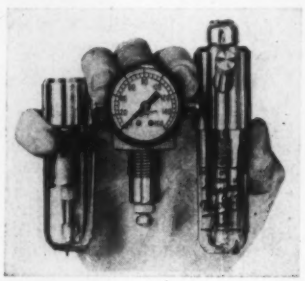
factured up to 2 in. or more in width. **William Brand & Co. Inc.**, Willimantic, Conn. B

Circle 721 on Page 19

Small Lubricating Units

are for air flows from 0.05 to 20 cfm

Two Lubro-Control units provide complete processing of compressed air for service to air cylinders, air chucks, air tools, bearings, and other machine components. They are available for air flows from 0.05 to 20 cfm. Smaller unit, for $\frac{1}{8}$-in. pipe installations, measures $4\frac{1}{2}$ in. wide, $4\frac{3}{4}$ in. high, and 3 in. deep. Larger unit for $\frac{1}{4}$-in. pipe installation measures $7\frac{1}{4}$ in. wide, $5\frac{1}{2}$ in. high, and $3\frac{3}{4}$ in. deep. Each lubricating unit consists of air filter, pressure regulator, and lubricator. Maximum line pressure is 150 psi, and maximum regulated



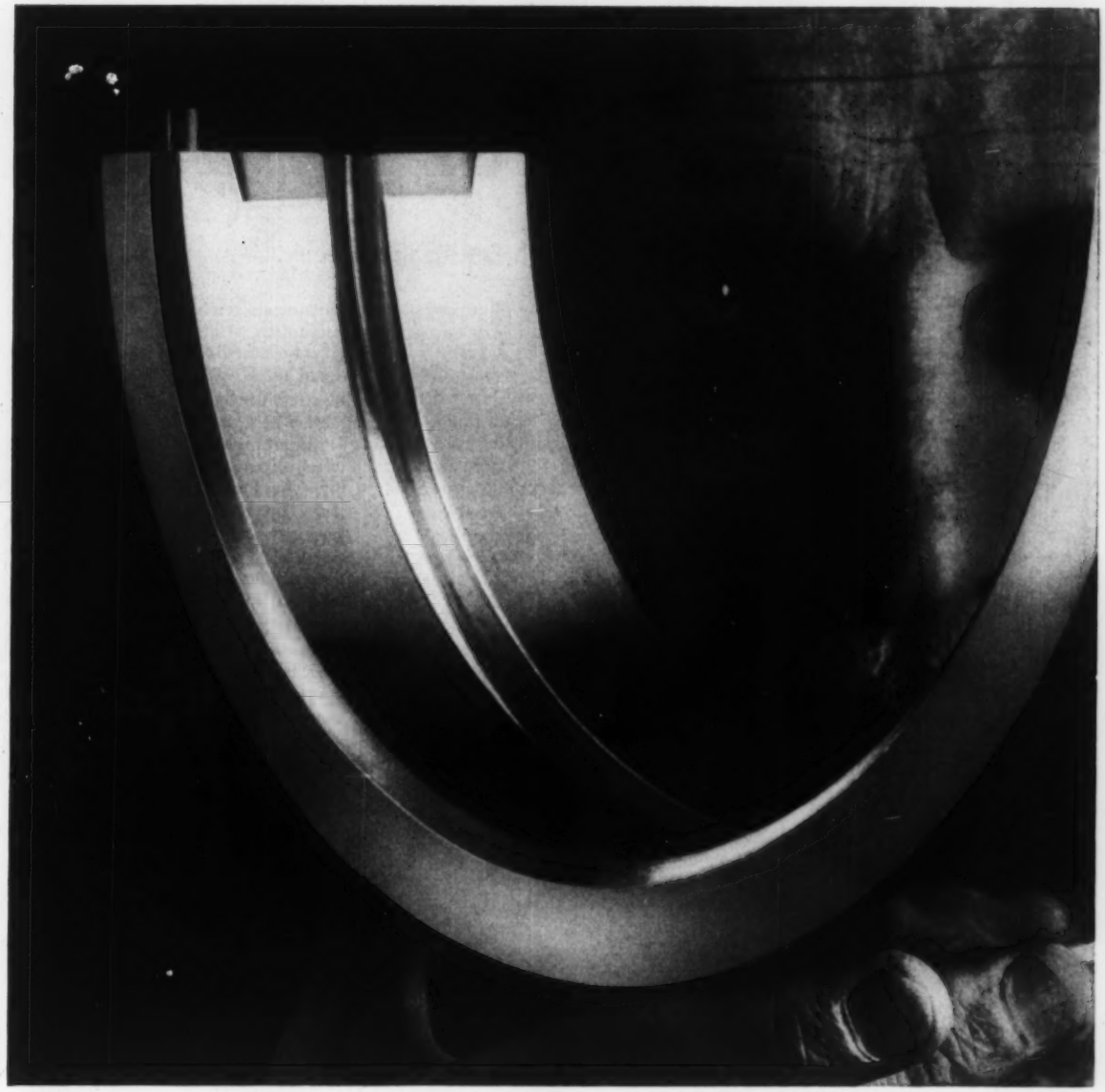
pressure is 100 psi. Maximum operating temperature is 120 F. **C. A. Norgren Co. Inc.**, 3400 S. Elati, Englewood, Colo. K

Circle 722 on Page 19

Direct-Reading Counter

operates continuously at 6000 rpm

High-speed, mechanical counter features a directly geared second wheel which reduces wear usually resulting from transfer-pinion methods. The direct-reading unit oper-



Alcoa Aluminum is today's best buy for bearings!

Here are the facts and figures for today's alert designers

Alcoa® Aluminum alloys do a *better* job in virtually every way. Strong words? Here are *facts* to back them:

Solid aluminum bearings, being nonmetallic in construction, protect costly shafts. Rugged service in a host of applications from railroads to rolling mills has proven their unmatched load-carrying ability. This means that with the same size bearing you can design for higher engine output. Or, if engine output is to remain the same, you can use a smaller bearing of aluminum and gain design advantages, such as: shorter and stiffer crankshafts, smaller and more compact engines and increased hp per cubic inch. In addition, aluminum bearings . . . RUN COOLEST of *all* bearing metals, because aluminum is the best heat conductor. Actual tests show heat reductions up to 20°F.

ALUMINUM BEARINGS last longest, because ductile aluminum *conforms* readily to misaligned shafts . . . has ideal *embeddability* for gritty particles . . . *resists corrosion* without additional protective coating . . . and is totally unaffected by the additives in today's lubricating oils.

ADD TO the list the fact that aluminum has very low starting friction under heavy load, high corrosion resistance and flexibility of design and manufacture. Then you have today's best buy in bearings. Why not have the *whole* story? For details, call your nearest Alcoa sales office, or write us at 1837-C Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM

Your Guide to the Best in Aluminum Value

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

Circle 546 on Page 19

Quick-Opening Fasteners: Screw Type or 1/4 Turn?

Know the features of each before you specify.

M. R. TUOZZO

The selection of a quick-operating door fastener usually involves a choice between two basic designs; the quick-acting screw fastener and the ¼ turn fastener. Both are relatively inexpensive. Each has advantages that make it the logical choice for certain applications.

THE SCREW FASTENER is a rugged, square threaded screw assembly engaging in a special heavy stamped nut. The nut is clipped, riveted, or welded to the door frame. A special washer behind the thread captivates the screw in an oversize hole in the door.

Because of its exceptional "float," it is installed without precision measurements and will always line up with ease. Where a variation in material thickness may occur or a gasket must be compressed, the screw fastener is preferred, since a single grip length can be used throughout. Under most conditions it will completely disengage in two to four turns. It offers excellent resistance to vibration and forms a solid joint with no "give."

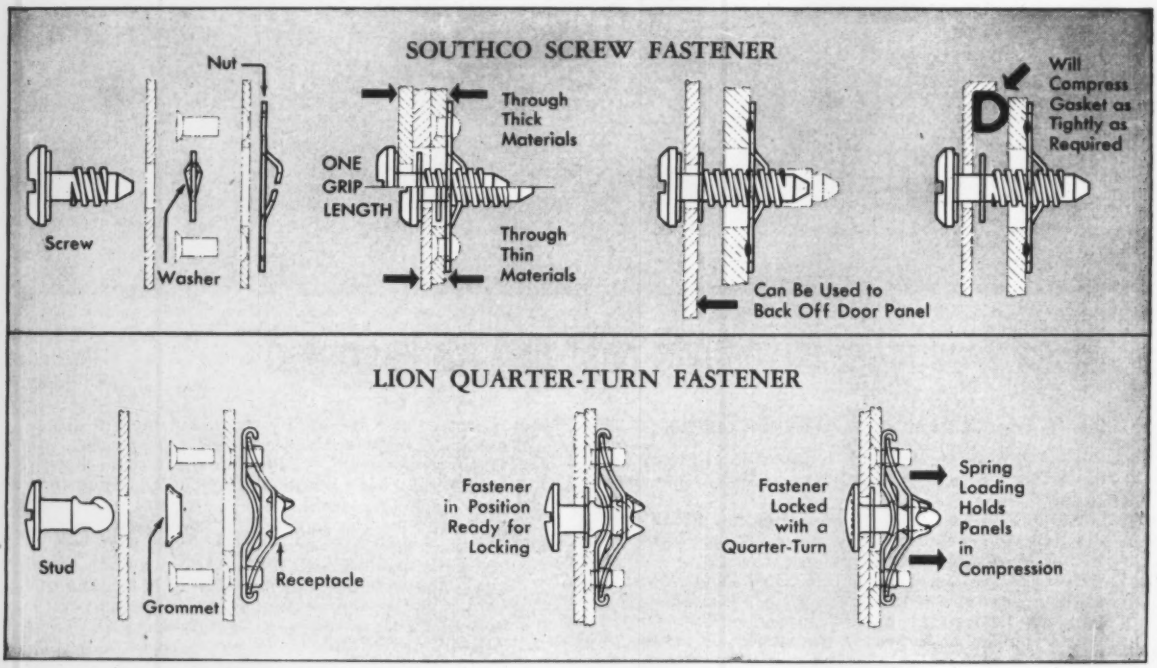
The screw fastener can be backed all the way out of the door frame without moving the door. If required, it can be installed so as to jack the door open as it is unscrewed.

THE QUARTER-TURN FASTENER is usually selected for application on aircraft (under Army-Navy-Air Force specification MIL-F-5591A) where instantaneous removal of fastened parts is required. As the name implies, it is quickly locked or unlocked by a fractional turn.

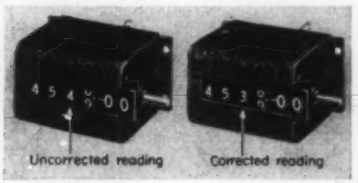
Its strength characteristics also are very high when the stud is formed from a single piece and no thin springs, wires, or cross pins exist in the assembly. The stud is retained in the door panel by a metal grommet, and engages in a full floating spring-loaded receptacle, riveted or welded to the door frame.

Where the thickness of door and frame are fairly constant through an entire production run, the quarter-turn fastener is a wise choice. Its design affords maximum speed in fastening, and excellent vibration resistance.

COMPARISON OF STANDARD QUICK-OPENING FASTENERS



SOUTHCO FASTENERS
LION
©1956
Southco Div., South Chester Corporation
237 Industrial Highway, Lester, Pa.



ates continuously at 6000 rpm. It also provides for instantaneously corrected direct reading in the event that second wheel is not fully within window. Counter is highly resistant to corrosion, humidity, and vibration, and has substantial life and low torque. White figures, 0.250 in. high, appear on black background. Case is approximately 2¾ in. long, 2 in. high, and 1½ in. deep. **Veeder-Root Inc.**, Hartford 2, Conn. B

Circle 723 on Page 19

Electroplated O-Rings

seal high pressures at elevated temperatures

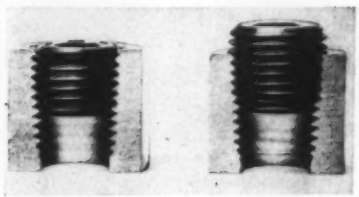
Electroplated metal O-ring seals have soft metal plating of 0.001 to 0.0015 in. thickness which flows into minute scratches or imperfections on sealing surfaces when ring is compressed. Plating permits use of flanges which might be rejected due to poor finishes, acts as a lubricant to prevent galling in screw-type applications, and permits high pressures to be sealed at elevated temperatures. Most used electroplate is silver; cadmium, nickel, copper, and gold are also available for specific applications. **Advanced Products Co.**, 59 Broadway, North Haven, Conn. B

Circle 724 on Page 19

Pressure Plug

seats flush with material into which it is threaded

Unbrako LevL-Seal (left), when installed in hydraulic, pneumatic, or other fluid-pressure systems, seats virtually level with material into



Solve Tough Molding Problems with Teflon* & KEL-F†

Our specialty is precision molding where close tolerances, intricate shapes, and where thin wall sections are involved. Garlock's United States Gasket Plastics Division has the personnel, the facilities, the unequalled experience in handling tough fluorocarbon plastics.

Guarantee yourself the best parts, and the right price—ask for a quote on any molding problem concerning TEFLON T.F.E. and KEL-F. Call us, too, for fluorocarbon sheets, discs, tape, rods, tubing, bars, and cylinders from the world's largest and most complete stock.

For Prompt Service, contact one of our 30 sales offices and warehouses in the U.S. and Canada, or write The Garlock Packing Company, Palmyra, New York.

*DuPont Trademark for T.F.E.-fluorocarbon resin
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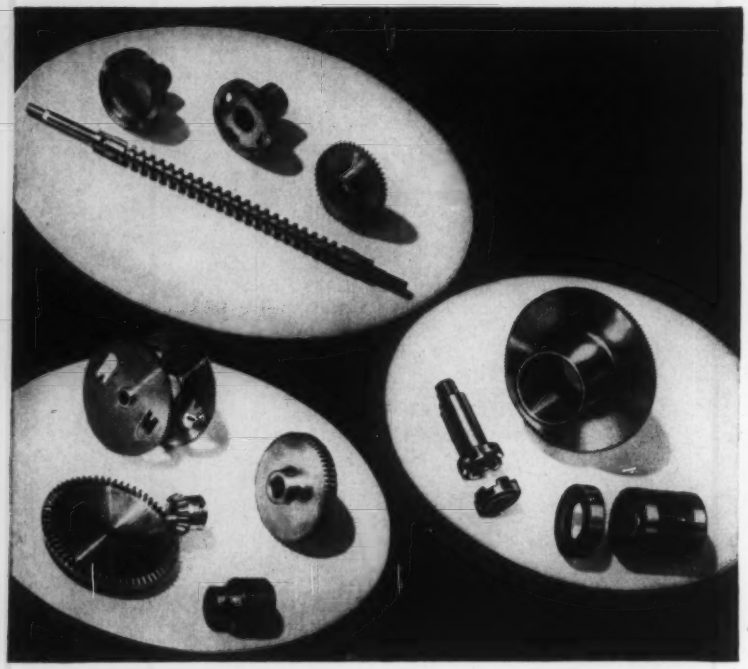
United States Gasket

Plastics Division of GARLOCK

Circle 548 on Page 19



small and fine pitch gears for precision equipment

No matter how fine your gear requirements — Perkins can solve your problems. Perkins unique custom-gear engineering service, available to your engineering staff prior to the blueprint stage, will . . . eliminate production headaches . . . cut excessive costs. This service — recognized by leaders in the radar, electronic and missile fields, and backed by 52 years of custom gear experience — assures the precision quality needed to guarantee trouble-free operation. Don't gamble with gear performance . . . Perkins skilled personnel, together with modern up-to-date equipment guarantees fast delivery on prototypes or production runs. Call or write Perkins for complete information on custom-gear engineering and a quotation on your requirements. Then judge for yourself.

YOURS ON REQUEST Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

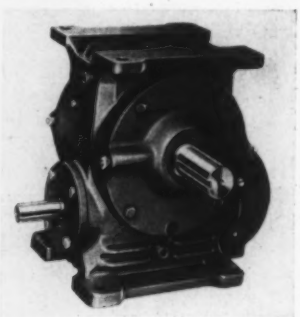
Dept. 73 West Springfield, Mass.
Telephone: REpublic 7-4751

which it is threaded. Seal has a different taper from that of tapped hole, providing positive, leakproof seal without compound even under high fluid pressure. Designed for use in standard $\frac{3}{4}$-in. per ft taper tapped holes, plug has taper of $\frac{7}{8}$ in. per ft. Seal is designed to seat flush within half a pitch. Thread form is NPTF Dryseal. Profile of thread on plug is such that it insures interference with mating threads at both crest and root as well as on flanks. Plug is available in standard sizes from 1/16 to $1\frac{1}{4}$ in. Material is alloy steel, heat treated for maximum strength. **Standard Pressed Steel Co.**, Stewart St., Jenkintown, Pa. C

Circle 725 on Page 19

Speed Reducer

worm-gear unit can be mounted in three positions



Available in $2\frac{1}{2}$, 3, $3\frac{1}{2}$, and 4-in. centers with up to $13\frac{1}{2}$ hp input rating and 7240 lb-in. output torque rating, worm-gear speed reducer can be mounted in three different positions: Worm shaft below gear (shown); worm shaft above gear; and output shaft vertical. One-piece cast-iron housing with external fins for cooling, and aluminum radial fan which directs air over fins insures high thermal rating. **Link-Belt Co.**, Dept. PR, Prudential Plaza, Chicago 1, Ill. J

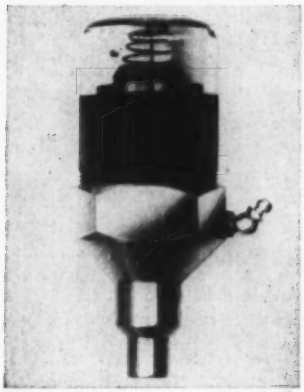
Circle 726 on Page 19

Automatic Grease Cup

for plain or antifriction bearings

Lubrimatic grease cup makes possible automatic self-feeding lubrication with visible control for all plain or antifriction bearings. Cups

Circle 549 on Page 19



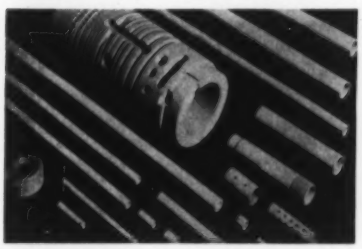
feature a large, 4-oz lubricant reservoir and vented, unbreakable, clear plastic cylinder for easy view of lubricant supply. Spring and weighted plunger feed grease to bearing with predetermined pressure, and protective valve seats when cup is full, preventing grease from entering bearing. Down-pressure grease gun fitting eliminates possibility of bending or breaking cups off while filling. Internal ⅛-in. pipe threads in housing permit any size pipe or extension to be used to mount cup. **Lubriquipment Engineers Inc.**, P.O. Box 9194, Ft. Worth 7, Tex. P

Circle 727 on Page 19

Laminated Tubing

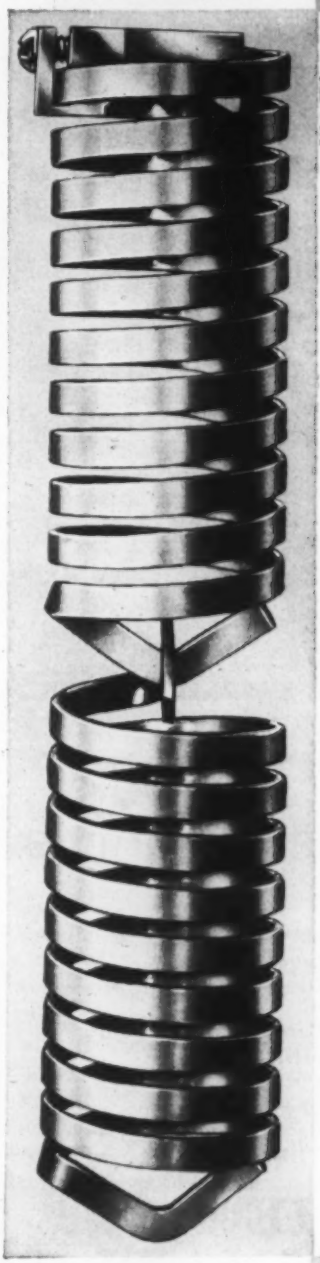
in ID to 12 in. and wall thickness to 2 in.

Insurok free-machining, paper-base, laminated rolled tubing is available in two additional grades which meet Military Specification MIL-P-79B or Federal Specification L-L-31, Type 1. Designated T-300 and T-301, tubes are easily fabricated without delaminating or chipping. They have a uniform appearance and are light in color. Typical properties of T-301 for a tube with 1-in. ID and ⅛-in. wall are 1 per cent water absorption, 19,000 psi compressive strength (axial), and



PRECISION TWIN EXTENSION SPRING

Available in practically all sizes and capacities



CHATILLON ISO-ELASTIC* makes this THE WORLD'S MOST ACCURATE SPRING

This type of Chatillon Iso-Elastic Twin Extension Spring is *used by every leading manufacturer of computing scales in the world.* Reason:—because it is *accurate to 1 part in 2,000!*

This extreme accuracy has induced companies like General Electric, Bendix, Pitney-Bowes, Sperry and many others who make precision instruments, to incorporate Chatillon Iso-Elastic springs into their designs.

The hysteresis error of this remarkable spring is less than .05% of deflection. Drift does not exceed .02% of deflection in 5 minutes. Combine these characteristics with temperature compensation and you have what is truly a *precision* spring in every sense of the word. Chatillon makes Spiral, Torsion, Compression and Form Springs of Iso-Elastic material, as well as springs of all conventional alloys.

We can help make your product better. Let Chatillon's Spring Division assist you. Write for engineering bulletins today.

* Chatillon's exclusive temperature-compensated spring material. U.S.A. Pat. No. 2174171.

Manufacturers of Scales, Force Measuring Instruments and Precision Springs Since 1835

JOHN CHATILLON & SONS
85 CLIFF STREET
NEW YORK 38, N.Y.

It's lots more fun...

Jim always came home grouchy and complaining about noisy gears and how did they expect him to build precision machines. But ever since the day he said they gave him a real batch of gears, made to order by CINCINNATI GEAR . . . he's my boy!

When it comes to gearing in your product, remember this **profit formula:**

Modern Manufacturing + Old-time Craftsmanship + Precision Inspection = CINCINNATI gears

For guaranteed custom gears and custom gear boxes, send your prints for our quotation.

CINTI®

THE CINCINNATI GEAR CO.

Wooster Pike and Mariemont Ave. Cincinnati 27, Ohio
Custom Gear Makers Since 1907

GEARS, good gears only

Circle 551 on Page 19

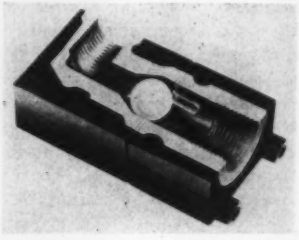
dielectric strength, perpendicular to laminations, of 400 v per mil minimum. Tubes are available with IDs to 12 in., wall thicknesses to 2 in., and lengths to 48 in. **Richardson Co.**, 2700 Lake St., Melrose Park, Ill. J

Circle 728 on Page 19

Check Valves

provide excellent corrosion resistance

Steel-armored Kemlon check valves with fluorocarbon construction on fluid-contact surfaces are impervious to almost every fluid except molten sodium. Offered in burst pressure



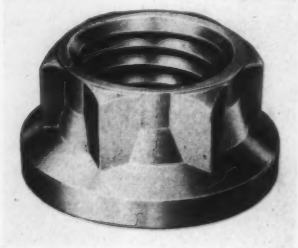
ratings to 1000 psi and over, they are recommended for severely corrosive service where valve failures due to balls sticking are a problem. Valves are available in ½, ¾, and 1-in. sizes, either threaded or 150-lb ASA flanged-body styles. Right-angle or in-line construction can be specified. **Keystone Engineering Co.**, 6315 England St., Houston 21, Tex. P

Circle 729 on Page 19

Lock Nut

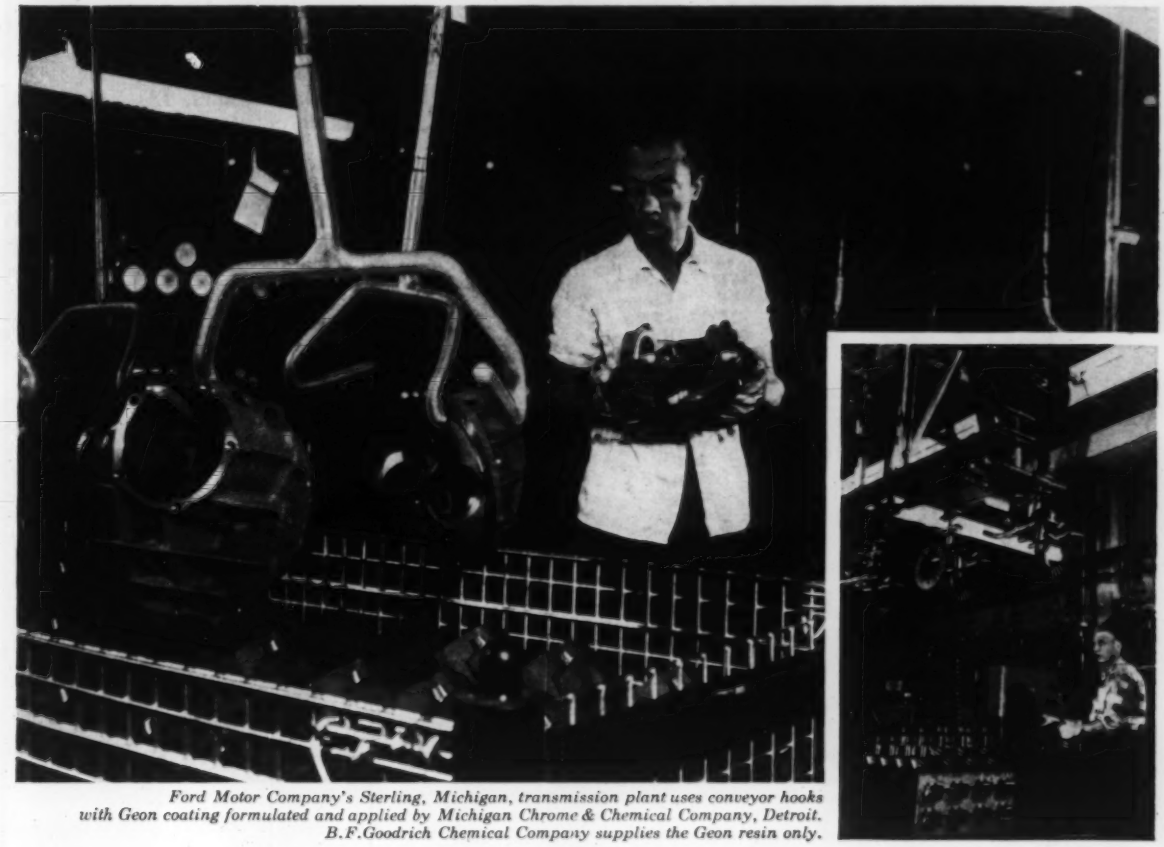
for 160,000-psi short-thread screws and bolts

H14 Kaylock low-height, self-locking nut is a lightweight unit for use with 160,000-psi short-thread screws and bolts. Wrenches for the nut are two sizes smaller than for standard AN and NAS nuts, per-



Another new development using

B.F.Goodrich Chemical *raw materials*



Ford Motor Company's Sterling, Michigan, transmission plant uses conveyor hooks with Geon coating formulated and applied by Michigan Chrome & Chemical Company, Detroit. B.F.Goodrich Chemical Company supplies the Geon resin only.

"Soft touch" of Geon safeguards parts quality

The overhead conveyor system in this automatic transmission plant uses 26,000 hooks coated with Geon polyvinyl material. The soft yet durable coating made from Geon protects finished parts while they are carried from machining to assembly stations.

In addition to giving the hooks a long and profitable service life, the Geon coatings come in any color, permitting color-coding for multiple conveyor operations.

Versatile Geon is ideal for many coating applications, since it disperses readily in the coating formula. Geon can be used to coat paper, textiles, metals or almost any material to provide new or improved advantages. Hundreds of types of Geon resins, plastics, latices and polyblends are available, tailored to specific uses for coatings, moldings, extrusions, or rigid or foam applications. For information, write Dept. **AS-1**, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

Circle 552 on Page 19

SCRAP PILE STEALING YOUR PROFITS?

It can, you know. For every last piece of it represents money — money that belongs in your profit pile, not your scrap pile.

How do you evict this larcenous lodger? It starts disappearing as soon as you call Wheelock, Lovejoy — your local steel service center. W-L offers an extensive variety of special alloy steels — and you get them *cut-to-size*. By ordering your steel as you need it, you can practically eliminate waste. And you save important floor space by reducing your inventory.

Complete W-L facilities — including expert metallurgical service — are at your disposal *now*. See listing below for the W-L Branch nearest you. For complete technical information on grades, applications, heat treating, etc., write today for your FREE COPY of the Wheelock, Lovejoy Data Book.

W-L STEEL SERVICE CENTERS – Cambridge • Cleveland Chicago • Hillside, N. J. • Detroit • Buffalo • Cincinnati

AGENTS – Southern Engineering Company, Charlotte, N. C.; Sanderson-Newbould, Ltd., Montreal & Toronto

WHEELOCK, LOVEJOY & COMPANY, INC.

134 Sidney St., Cambridge 39, Mass.

AMERICAN STEEL WAREHOUSE ASS'N

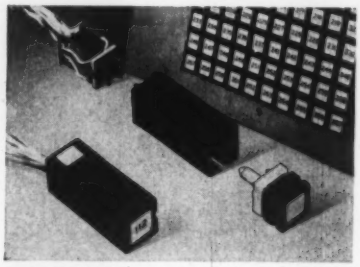
mitting use of narrower flanges and allowing bolt to be placed closer to load centerline. Nut is also available in A286 corrosion-resistant steel for 900-F temperature. **Kaynar Mfg. Co. Inc.**, Box 2001, Terminal Annex, Los Angeles 54, Calif. L

Circle 730 on Page 19

Pushbutton Switches

lighted units can be mounted in common hole

C-20 switches are double-lighted with two No. 327 bulbs. Having square, modular construction, units mount in 7/8-in. square hole. Button and light assembly is removable from front of panel for easy relamping. Any number of units mount side by side in common hole. Optional baffle permits lighting



half of button. Two bulbs can be of different colors, and each can indicate two functions by using steady or flashing light. Two 28-v bulbs are provided. **Electrosnap Corp.**, 4218 W. Lake St., Chicago 24, Ill. J

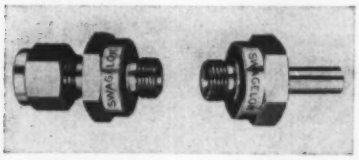
Circle 731 on Page 19

Connectors and Adaptors

male units incorporate O-ring seal

Swagelok O-Seal fittings have tapered pipe threads, permitting connection to existing female pipe thread and securing positive seal without use of contaminating sealants. Seal is built integrally into body of fittings. When tightened against its mating surface, it eliminates possibility of leak. Fittings can be used for pressure connections or high-vacuum applications with rigid leakproof requirements. Designed for use in standard female pipe-thread connections, connectors and adaptors are installed in a

Circle 553 on Page 19



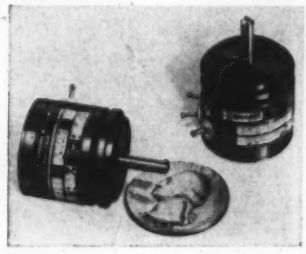
short time. Tightening with wrench assures positive, leakproof seal. Fittings are available in all machinable metals and plastics in sizes for 1/16 through 1-in. OD tubing. Seal is furnished in a variety of materials to meet requirements. **Crawford Fitting Co.**, 884 E. 140th St., Cleveland 10, Ohio. G

Circle 732 on Page 19

Subminiature Potentiometer

provides linearity to ± 0.1 per cent of full scale

Model 875 precision potentiometer weighs only 5/8 oz and is 0.875 in. in diam. Instrument offers resolution as high as 0.06 per cent and linearity of ±0.1 per cent. Resistance ranges from 200 through 100,000 ohms per section are available. Unit is wire wound and has servo mount. Up to four sections can be ganged on a common shaft. Potentiometer is for use in applications where there is a need for potentiometers of high resolution and excellent linearity, such as in mis-



siles, jet engine instrumentation, airborne computers. **G. M. Giannini & Co.**, 918 E. Green St., Pasadena 1, Calif. L

Circle 733 on Page 19

Wiring Duct

is all white to match JIC control panels

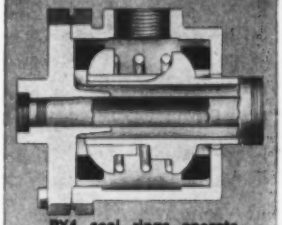
High light reflectance of white Panduct permits good internal visibility, making wire installation and tracing easy and minimizing visual fatigue. The all-white wiring duct matches white interiors of con-

You can depend on

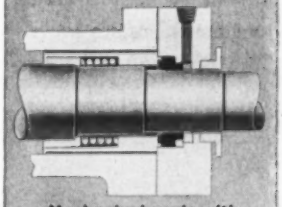
PY4

Morganite

SEALS



PY4 seal rings operate with highest efficiency in this rotary pressure joint carrying steam-condensate.



Mechanical seals with Morganite PY4 noses provide an extra measure of dependability in this stuffing box assembly.

Application tested for all sealing requirements

Service-proven on toughest assignments

LINK PY4 GRADE of self-lubricating MORGANITE is the engineer-preferred seal material for every application where premium performance is a "must." Actual service records compiled on PY4 Seals in all types of rigorous service, prove that this super-rugged material can take punishment! PY4 Seals function with highest efficiency in the presence of grease, searching liquids, corrosives, high pressures and high temperature. Install Morganite LINK PY4 for longer seal life . . . reduce down-time and save on seal replacement costs.

AVAILABLE WORLDWIDE—Send drawings and operating data for a recommendation on your specific seal requirements.

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Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts... Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

Circle 554 on Page 19

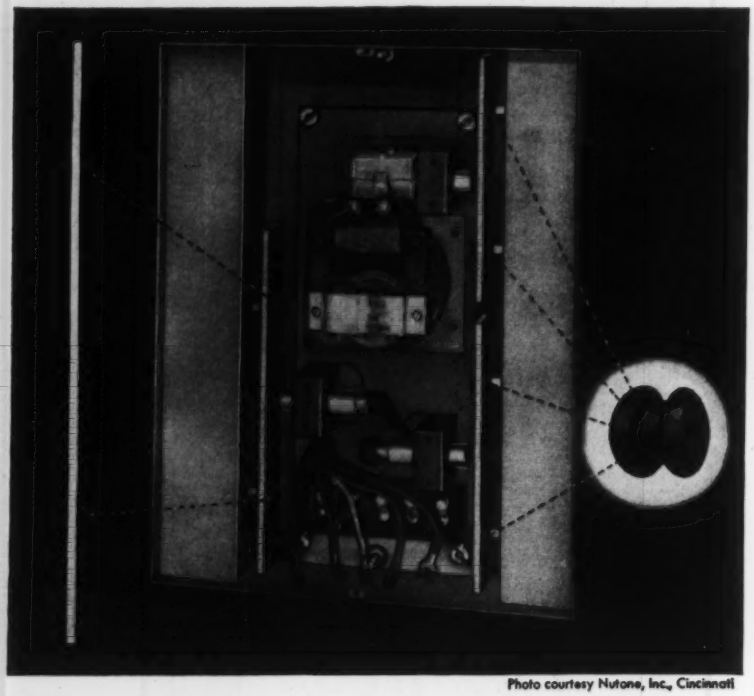


Photo courtesy Nutone, Inc., Cincinnati

Engineers Develop New Use for Rubber

Rubber, normally used to *reduce* vibration, now can be made to *increase* vibration

Here rubber grommets serve as mountings for the tone bars in Nutone Door Chimes. To obtain maximum tone quality and resonance required of these musical chimes, the grommets must vibrate compatibly with the tone bars . . . a truly *unusual assignment* for rubber.

Only by skillful compounding can rubber be diverted from its normal dampening characteristic and be given this vibrant quality. The slightest deadening effect would destroy the rich tones and kill the tone hang.

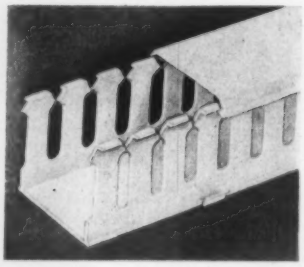
The successful development of this lively, age-resistant rubber stock typifies the complete engineering and laboratory—as well as manufacturing—skill available at Continental. Whenever you need "engineered rubber parts" — molded or extruded, natural or synthetic—call Continental, Specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA



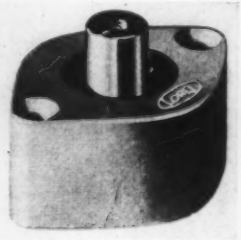
trol panels as required by JIC. Material is polyvinyl chloride plastic which incorporates no fiber fillers, is durable and nonflammable. Duct is available in 19 standard sizes from ½ x ½ to 3 x 4 in. Designs include open slot, closed slot, and wire hole designs. Standard length is 5 ft, with 6 or 7-ft lengths also available. **Panduit Corp.**, Dept. MDC, 14461 Waverly Ave., Midlothian, Ill. I

Circle 734 on Page 19

Elastomeric Mountings

for small airborne electronic units

Two mountings, designated HTO-1 and HTO-2, have load capacities of 1 and 2 lb respectively. Unit weight of each is only 1 oz. Mountings have broad temperature operation from −65 to 300 F, extreme environmental resistance, all-



attitude protection, isolation of frequencies to 2000 cps, and high internal damping. They are designed especially to protect small electronic units in jet aircraft and guided missiles. **Lord Mfg. Co.**, 1635 W. 12th St., Erie, Pa. F

Circle 735 on Page 19

Miniature Coupling

self-sealing unit is for operating pressures to 1500 psi

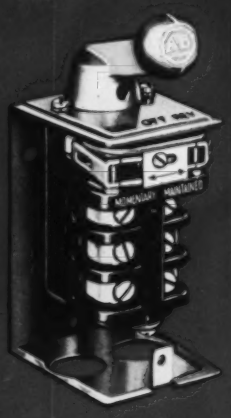
Series 1010 coupling is suitable for electronic cooling systems, test stand, filling and charging connec-

Circle 555 on Page 19

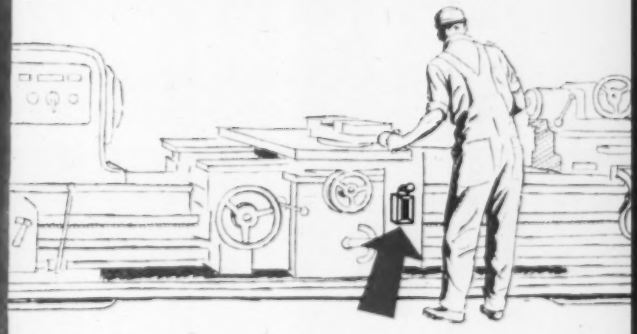
Circle 556 on Page 19→

ALLEN-BRADLEY

REVERSING DRUM SWITCHES



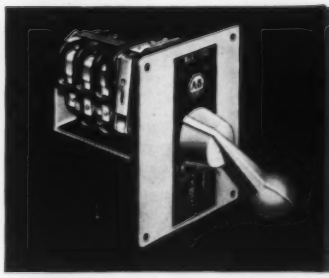
BULLETIN 350
Style A wrap-around cover is removed to show the readily accessible front wiring terminals. Max rating: 2 hp.



...styled to match the most modern production machines!

Inside and out—this Allen-Bradley drum switch is *all* new. Its trim, modern lines and attractive die-cast aluminum handle will give your production machines "up-to-the-minute" styling.

But there is more than beauty to this new switch. The rugged switch mechanism is a self-contained unit—independent of the enclosure. Misalignment and binding *cannot* occur. The base mounts directly on machine surfaces—without using spacers. And with the wrap-around cover removed, terminal screws are exposed for fast wiring—from the front. Changeover from momentary to maintained contact operation can be made in seconds. Investigate this new "leader" in its field. Send for Publication 6091.



OILTIGHT CAVITY MOUNTING
A-B Style AF reversing switches can be furnished with sealed shaft and rubber-gasketed, oiltight cover for cavity mounting in a machine base.

PANEL MOUNTING
The new Style A switches can be furnished for mounting directly on panels. Nameplate which gives ratings is also included with each switch.

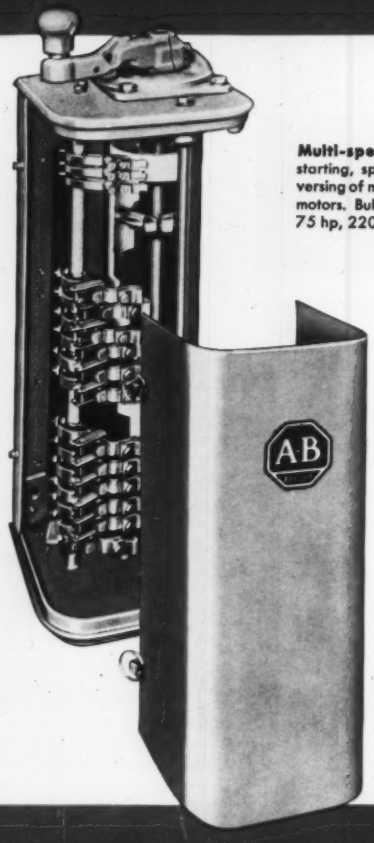
ALLEN-BRADLEY

Quality Motor Control

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

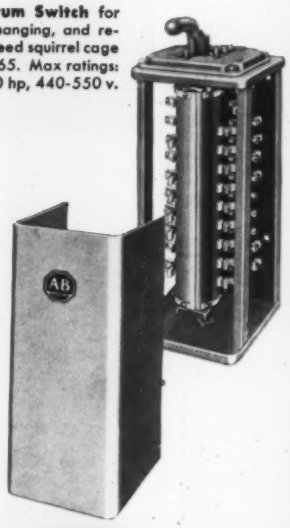
3-59-MR

Reversing Drum Switch for across-the-line starting and reversing a-c and d-c motors. Interlocks available. Bulletin 350. Max ratings: A.C. 20 hp, 220v; 40 hp, 440-550v. D.C. 3 hp, 115-230v.



Speed Regulating Drum Switch for starting and regulating duty of wound-rotor motors. Bulletin 375 non-reversing. Max ratings: 500 hp, 220-440-550 v. Bulletin 385 reversing. Max ratings: 60 hp, 220 v; 75 hp, 440-550 v.

Multi-speed Drum Switch for starting, speed changing, and reversing of multi-speed squirrel cage motors. Bulletin 365. Max ratings: 75 hp, 220 v; 150 hp, 440-550 v.



A-B QUALITY

For years of dependable performance

ALLEN-BRADLEY DRUM SWITCHES

have no equal!

These Allen-Bradley drum switches provide simple and economical control for alternating current motors. Although low in cost, these unusually rugged switches are built under Allen-Bradley standards of *quality* . . . your assurance of reliable, trouble free performance. And this broad line of drum switches offers a variety of mounting types, operating handles, and interlocks to satisfy practically every requirement. Let us send you details on this versatile line of drum switches.

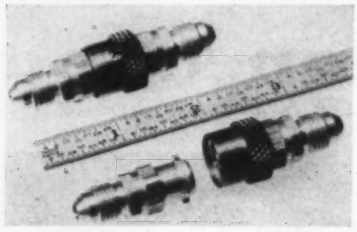
ALLEN-BRADLEY

Quality Motor Control

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

3-59-MR

tions, pressure sensing, and other general aircraft or missile applications where light weight and compactness are needed. Unit is only 2½ in. long and weighs slightly over ½ oz. Connection is by bayonet-type lock, and each half is



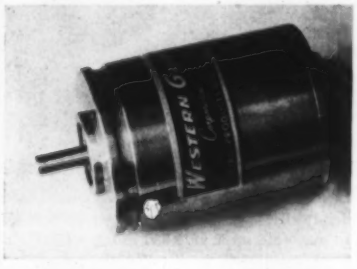
self sealing with O-rings of Viton A. Design exceeds requirements of MIL-C-7413. Coupling has operating temperature range of −65 to 375 F, with operating pressures to 1500 psi. **Aeroquip Corp.**, Jackson, Mich. H

Circle 736 on Page 19

Synchronous Motors

have pull-in torque of 0.12 oz-in.

Size 10 and 11 hysteresis synchronous motors are available for 26, 55, or 115-v ac, 400-cycle operation. The six-pole units have pull-in torque of 0.12 oz-in. and operate at 8000 rpm. They are for use in



ambient temperatures from −65 to +125 C. Motors measure 1 11/32 in. in length. **Electro Products Div., Western Gear Corp.**, 132 W. Colorado St., Pasadena, Calif. L

Circle 737 on Page 19

Epoxy-Glass Laminate

has high tensile and impact resistance

No. 11559 transparent Textolite industrial laminate is designed for computer circuits and military electronic applications. The self-extinguishing epoxy-glass laminate has 20 million megohms insulation resistance at 50 C and 500,000 megohms resistance at 165 C. It retains 65 per cent of room temperature flexural strength at 150 C. Classified NEMA Grade G-11, laminate has high tensile and impact resistance. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 738 on Page 19

High-Pressure Hose

in sizes from 3/16 to 2 in. ID

Super-Spiral hose is available in four and six-ply spiral-wound, wire-reinforced styles. Sizes range from 3/16 to 2 in. ID. Maximum working pressure is 10,000 psi for four-ply and 12,500 psi for six-ply in 3/16-in. size, to 2500 psi for four-ply and 3000 psi for six-ply in 1½-in. ID size. Wire reinforcements

are all spirally wound with complete absence of wire braid. Use of spiral-wire construction permits use of 0.022-in. wire and eliminates crossed wires of braid, reducing wire fatigue. Hose is available in assemblies equipped with any style Anchor pressed-on coupling. **Anchor Coupling Co. Inc.**, 342 N. Fourth St., Libertyville, Ill. D

Circle 739 on Page 19

Pulse Counters

generate up to 120 counts per revolution

Transistorized zero-speed Rotopulsers are for industrial automation applications, such as continuous process measurements for length, rpm, linear or angular position, belt speed, motor slip, or for almost any physical quantity which can be converted into shaft rotations. Rotating-shaft pulse counters generate up to 1200 counts per revolution, and measure length down to 0.01-in. increments with 12-in. circumference counting wheel. Operating speeds range above 10,000 rpm with constant output at all speeds. Units can be used 100 ft or more away from control equip-

Another PLUS value...

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Want continuous production...to cut installation costs? Investigate the advantages of Rex Segmental Rim Sprockets and Traction Wheels. Tough, long-lasting special cast steel rims bolt simply to either split or solid hub body. When, after long service life, replacement is required, all you do is replace the worn rim...the hub body remains on the shaft. Mail the coupon.

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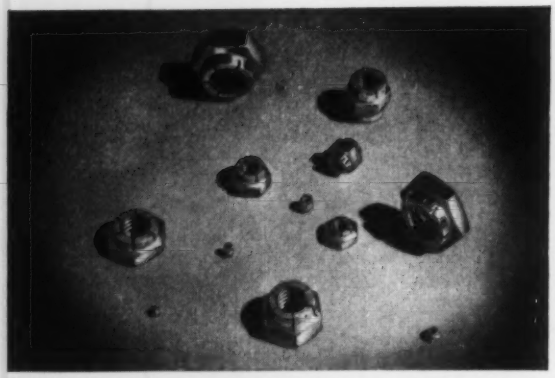
Address.....
City.....*Zone*.....*State*.....

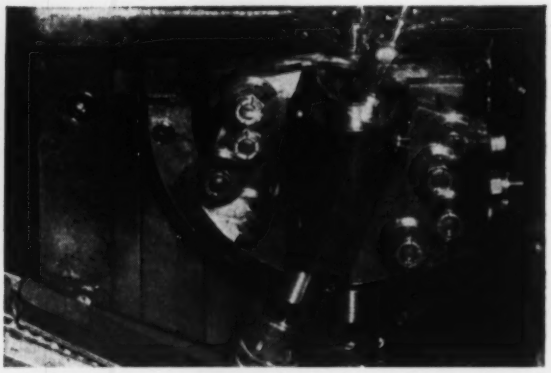
Circle 557 on Page 19

SPS RELIABILITY / *A dynamic standard of predictable performance*

There's a FLEXLOC locknut for every application need

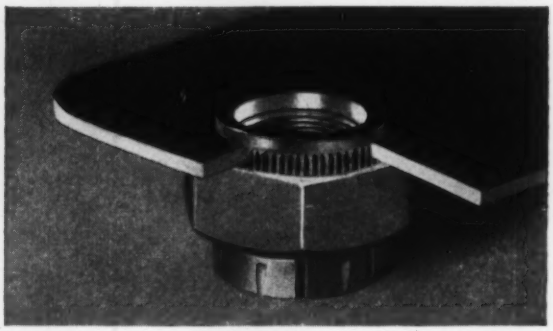


FLEXLOC self-locking nuts are available in alloy steel (plain or cadmium plated) for temperatures to 550°F.; in corrosion-resisting steel (passivated or silver plated) for temperatures to 750°F.; and in brass (plain or cadmium plated) and aluminum (plain or chemically treated) for temperatures to 250°F.



Stroboscopic photo shows application of full-height FLEXLOC locknuts on the transfer injector of a nut finishing machine. Despite constant rockerlike motion of the injector arm, FLEXLOCs do not work loose. Full-height FLEXLOCs are available in sizes #2 through 2 in.; also in microsizes #0 through #4.

FLEXLOC thin nuts are used here as stop nuts on the stamping attachment of a milling machine; resist thousands of impacts an hour. Thin FLEXLOCs are furnished in sizes #6 through 1½ in.; are designed for use where weight savings are important or where locking action is desired with shorter bolts.



FLEXLOC clinch nuts simplify fastening to sheet metal; aid in blind fastening. Clinch nuts are available in sizes #4 through 5/16 in.; also in microsizes #0 through #4. Cutaway view shows how FLEXLOC becomes an integral part of the completed assembly. FLEXLOC functions as a tapped hole—one that will lock a screw securely in place.

Wherever you have a requirement for vibration-proof nut assembly, there is a FLEXLOC self-locking nut to meet it. And FLEXLOCs are available to you locally from a single source of supply. Your SPS distributor carries them in a complete range of types, sizes, materials and finishes. This simplifies your paper work and insures prompt delivery.

FLEXLOCs are 1-piece, all-metal fasteners requiring no auxiliary locking devices—no lockwashers, jam nuts or cotter pins. There is nothing extra to put together, come apart or get lost. Thus FLEXLOCs facilitate design and save assembly time. They also save on maintenance, because they can be reused repeatedly without loss of locking reliability. See your authorized SPS distributor for complete information on FLEXLOC self-locking nuts . . . or write SPS—manufacturer of precision threaded fasteners, including titanium. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

SPS

Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

Circle 558 on Page 19

ment without loss of reliability or accuracy. Counters have no gears or contacts, negligible torque, and are completely enclosed to withstand wide temperature ranges. **Dynapar Corp.**, 5150 Church St., Skokie, Ill. J

Circle 740 on Page 19

Silicone-Rubber Cement

for rubber-to-rubber and rubber-to-metal bonds

C-319 silicone-rubber cement can be used to bond silicone rubber to silicone rubber or to metal. It is a two-part material consisting of a low-temperature, flexible, high-tensile, high-strength silicone-rubber solution with about 35 to 40 per cent solids, and a nonvolatile, room-temperature vulcanizing catalyst in solvent. Bonds attained have excellent low-temperature resistance. Brittle point is well below −100 F, and high-temperature limit is about 350 F. **Connecticut Hard Rubber Co.**, 407 East St., New Haven, Conn. E

Circle 741 on Page 19

Control Valve

two-way unit is for pressures to 5000 psi

Two-way valve allows independently controlled flow in either or both directions. It is available in standard inside port sizes from ⅛ to ¾ in., and is adaptable to hydraulic or pneumatic applications in pressures to 5000 psi. Valve is female threaded to dryseal specifications and is available in brass,

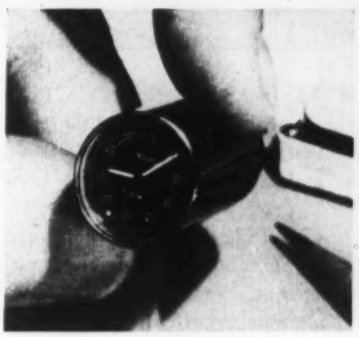
steel, aluminum, stainless, and special alloys. Design eliminates internal gaskets, springs, and hinged parts, permitting low friction loss and good flow at all temperatures. Valve can be adjusted before, during, or after installation with common screwdriver. Straight-through ball-valve principle permits sensitive adjustments and lessens clogging. **True-Flo Valve Co. Inc.**, 79 Bow St., Everett 49, Mass. B

Circle 742 on Page 19

Elapsed-Time Indicator

miniature unit records up to 1000 hr

Microminiature indicator has diameter of 0.655 in. and length of 1.416 in. Unit incorporates 1-w synchronous motor which runs on 115-v, 400-cycle current. Designed for use in measuring reliability of aircraft and missiles components, it has a jewelled gear train with 180



million-to-one ratio. Unit records up to 1000 hr, and contains an internal reset. It resists vibration to 10 g at 500 cps and shock to 15 g. Indicator operates in temperature range of −40 to +165 F. **Elgin-Micronic Div., Elgin National Watch Co.**, 366 Bluff City Blvd., Elgin, Ill. J

Circle 743 on Page 19

Sealed Thermostat

for operating range of −20 to 167 F

Series 20420 Klixon thermostat, designed with sealed construction for refrigeration and air-conditioning applications, is also suitable for other applications where a sealed construction is required. Operating range is −20 to 167 F. Unit is available with various configurations for

Another PLUS value...

POSITIONED TO HANDLE LOADS

To provide the ability to stand up under heavier loads and higher speeds, bushings in all Rex Roller Chains are carefully positioned in the link plates with the seams facing each other on the pitch line. Thus, the load is always *on* the strongest part of the bushing...always *away* from the seam. It's one of the many *PLUS VALUE* features of Rex Roller Chains that make them first choice where maximum fatigue strength and wear life are required. For all the facts, mail the coupon.

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Company.....
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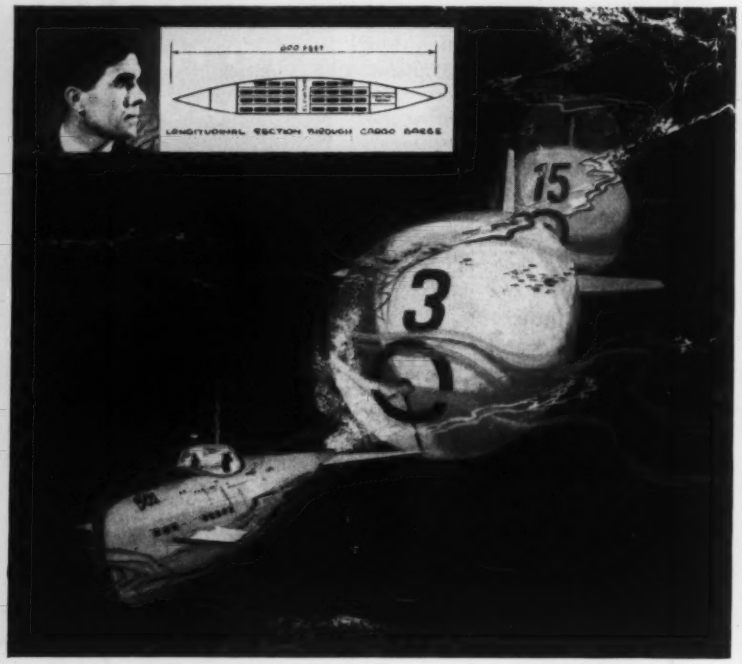
Circle 559 on Page 19

No. 16 • Mars Outstanding Design Series



UNDERWATER CARGO – P. J. Carroll, M. E., of Dublin, Ireland, has developed this ingenious method of underseas shipping.

The tug, powered by nuclear reaction, tows a string of cargo vessels, taking advantage of ocean currents and sub-polar routes – free from delays due to weather or tides.

Power supply is adequate for years and tug can remain submerged indefinitely. It can transport cargo to and from many ports without surfacing, since based-in-port auxiliary submarine vessels uncouple the cargo carriers from tug and lead them into underwater pens. There cargo, stored in containers, is transferred by elevators and conveyors to trucks which are then sped by nuclear powered mono-rail to principal distribution points.

This nuclear-age concept of shipping is one more example of the contributions that today's designers are making. To help them translate their pace-setting ideas from concept to reality, they require the best of drafting tools.

In pencils that means MARS, long the standard of professionals.

Among the famous imported Mars drafting products are: **Left** – 1001 Mars-Technico push-button lead holder. **Above** – 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. **Below** – 2886 Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; 2830 Mars-Lumograph Duralar–for drafting on Mylar®-base tracing film – 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. **Not shown** – Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

Mars Products are available at better engineering and drafting material suppliers.

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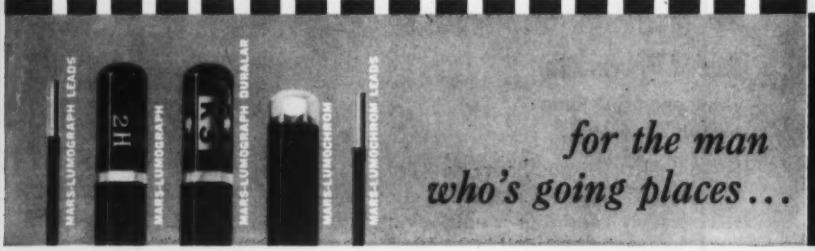

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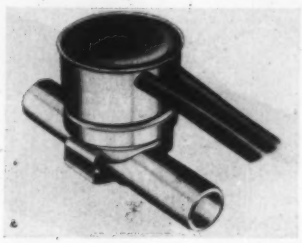
the pencil that's as good as it looks **MARS**

Sold at all good engineering and drawing material suppliers • J. S. STAEDTLER, INC. • Hackensack, N. J.

mounting on tubing or flat surfaces. Snap-acting, disc-type thermal element provides clean, heavy-duty switching, and copper cup assures quick transmittal of temperature



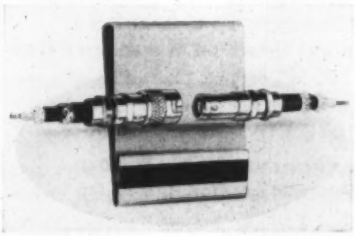
change to disc. Thermostat can be used as a fan switch or as a high-limit control. Fixed temperature settings give spot temperature control, unaffected by altitude or cross-ambient effect, at point of thermostat application. Temperature settings are highly resistant to vibration. **Versailles Products Div., Metals & Controls Corp.**, Versailles, Ky. G

Circle 744 on Page 19

Miniature Connectors

triaxial units have Teflon insulation

Miniature cable connectors are available in four different polarity groups, and withstand cable pull of over 50 lb. Plugs and jacks measure only 1 x ⅜ in., yet provide two separate concentric shields, accommodate cables to 0.212 in. OD, and have 500-v rate capacity. Connectors can also be used with coaxial cable



from 0.060 to 0.250 in. OD where underground systems are required. **Dage Electric Co. Inc.**, 67 N. Second St., Beach Grove, Ind. J

Circle 745 on Page 19

Hydraulic Motorpump

miniature unit is for pressures from 0 to 1000 psi

Vane-pump, electric-motor combination is designed for low-pressure circulation of coolant oil in missile electronic gear, missile-skin cooling, electronic-chassis cooling, fuel and lubricating pumps, small radar and computer drives, and for use as a remote power supply. The miniature unit has output range of 0.6 to 1.5 gpm at 11,300 rpm and 1000 psi. Capacities can be increased by using multiple vane-pump cartridges stacked in an integral housing, or by using double-ended motors. Pressure can be varied from 0 to 1000 psi, and unit operates in temperatures from −65 to 225 F. Vane-pump can be manifolded with servo valves, miniature-

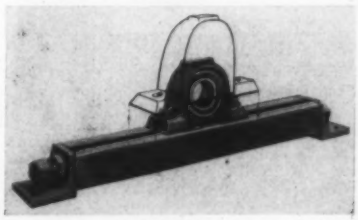
piston hydraulic motors, and fractional-horsepower electric motors. **Vickers Inc., Div., Sperry-Rand Corp.**, Detroit 32, Mich. H

Circle 746 on Page 19

Take-Up Frame

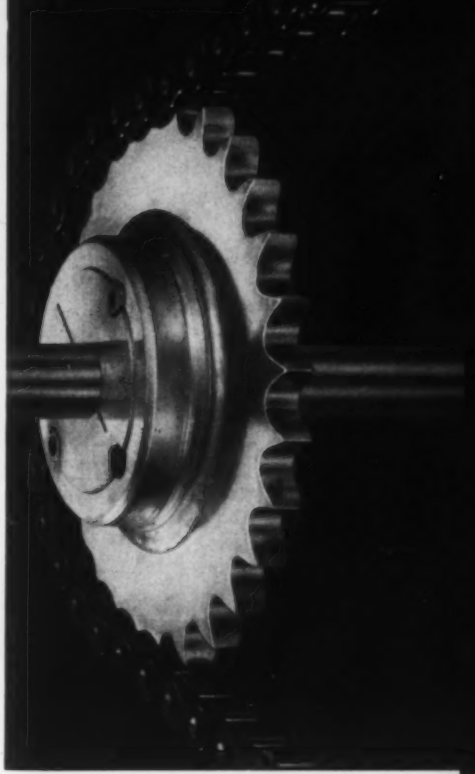
permits use of any pillow block

Versa Mount can be top or side mounted, and accommodates all types of pillow blocks. Large nut is mounted on both ends of adjusting screw, each ending with a heavy steel rod pin. Nut permits easy disassembly and removal of all parts without special tools, and all parts can be individually replaced. Adjusting screw is enclosed for protection against dirt and contamination. Wide range of sizes and travel lengths from 2 to 36 in. is available from stock. Units accommodate any type or make of pillow block from



Another PLUS value...

CUT RIGHT...
NOT
"CUT RATE"



Sprockets that are *not* cut right can cut chain life by as much as 50% to 75%. For smoothest action...for maximum service life of both chain and sprockets, cut-tooth sprockets must be made to precise tolerances. Rex Cut-Tooth Sprockets are made to exact tolerances to fit precisely with the chain for longest life of both chain and sprockets. For more data, mail the coupon.

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CUT-TOOTH SPROCKETS

CHAIN Belt Company 408
4643 W. Greenfield Ave., Milwaukee 1, Wis.
(In Canada: CHAIN Belt Canada Ltd., 1181 Sheppard Ave. East, Toronto, Ontario.)
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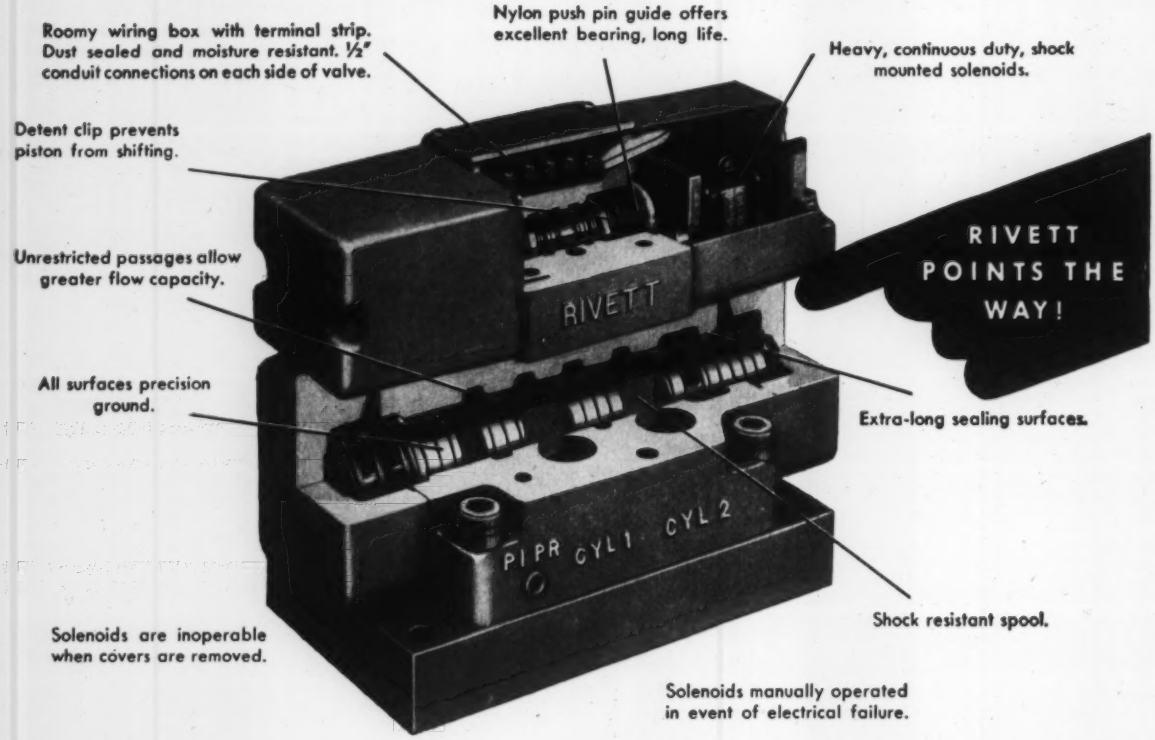
Circle 561 on Page 1v


Roomy wiring box with terminal strip. Dust sealed and moisture resistant. ½" conduit connections on each side of valve.
Nylon push pin guide offers excellent bearing, long life.
Heavy, continuous duty, shock mounted solenoids.
Detent clip prevents piston from shifting.
Unrestricted passages allow greater flow capacity.
All surfaces precision ground.
RIVETT POINTS THE WAY!
Extra-long sealing surfaces.
Shock resistant spool.
Solenoids are inoperable when covers are removed.
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High Flow Capacity!

Rivett's New Solenoid Pilot Operated Hydraulic 1" Valve Is Rated at 28 G.P.M. and the 1½" Size At 82.5 G.P.M., At 15 Ft. Per Sec. Velocity.

- Reduces Back Pressure, Friction, Heat
- Opens and Closes Smoothly, Positively
- Mounts In Any Position
- 3000 P.S.I. Operation for Multi-Million Cycles
- Optional: Built-in Speed Controls
  Explosion Resistant
  Solenoid Enclosures

Forget about back pressure by specifying Rivett 6600's for service up to 3000 P.S.I. Reduce inventory! Select off the shelf: 2 basic sizes fit ⅜", ½", ¾", 1", 1¼" and 1½" I.P.S. Single and double solenoid. 7 spool designs. Meet *all* J.I.C. requirements.

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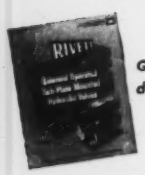


Get Catalog No. 261 to aid your circuit design. Complete drawings, specifications, cut-away views, tables, diagrams!

Member National Fluid Power Association

RIVETT
"100"
HYDRAULIC VALVES

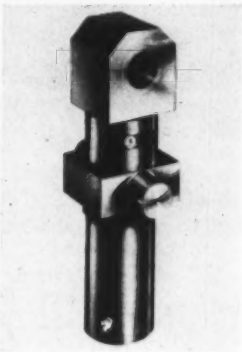
½ to 2 7/16 in. Mount is also recommended for motor-base, head-shaft support, and similar applications. **Lovejoy Flexible Coupling Co.**, 4882 W. Lake St., Chicago 44, Ill. J

Circle 747 on Page 19

Liquid-Spring Shocks

are self-contained, heavy-duty units

Series 900 heavy-duty liquid-spring Shoks have 1 million lb spring force using liquid compressibility. Springs are equipped with any type standard end mountings and have energy storage or absorption capacities in both directions up to 1 million pounds force. Adjustable



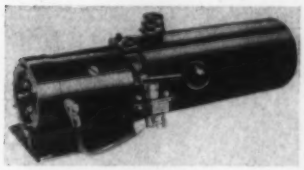
dampening force and time-delay return can be built into the units. Shocks are available in 2, 3, 4, and 5-in. diam with up to 2 in. stroke. **Taylor Devices Inc.**, 188 Main St., North Tonawanda, N. Y. N

Circle 748 on Page 19

Hydraulic Power Unit

has built-in control options

Series GC-2405 is a fluid-power source for tractors, dock-leveling devices, tailgate lifts, dump bodies, snow plows, cement mixers, lift trucks, and other types of work loads. Unit mounts in any position. It has rotary gear-pump capacities of ½ to 4 gpm at 1800 rpm, with increased delivery at 3600 rpm. Unit is for pressures to 2000 psi. Reservoir has diameter of 4¾ in. in lengths of 6, 9, and 12 in. for 1¼, 2⅛, or 3-qt capacities. Diameter of 6⅝ in. is also available for larger volumes to 2 gal. Direct, belt, or special drives are provided. Unit has continuous or intermittent ball-bearing motor. Built-



in control options include check and/or relief valve, manual or solenoid-operated lowering valves, and unloading valves. **Constant-Flo Div., John S. Barnes Corp.**, 301 S. Water St., Rockford, Ill. K

Circle 749 on Page 19

Insulating Material

has excellent temperature stability

Enrad II is an improved form of irradiated polyolefin which exhibits excellent mechanical and electrical properties. Dielectric strength is on the order of 1000—almost twice that of linear polyethylene. Low dissipation factor of 0.0005 makes material well suited for high-frequency applications. Applications include electrical insulators, tube sockets, connectors, and wire insulation. High bond strength makes material useful as a copper-clad laminate for printed circuits. Material retains excellent form stability to beyond 300 C. It will not melt at any temperature and remains hard and tough with little or no cold flow at low temperatures. Material can be molded in both simple and complex shapes with complete uniformity of properties. It is available as a powder, or as bars, rods, and sheets. **Enflo Corp.**, Fellowship Road and Route 73, Maple Shade, N. J. D

Circle 750 on Page 19

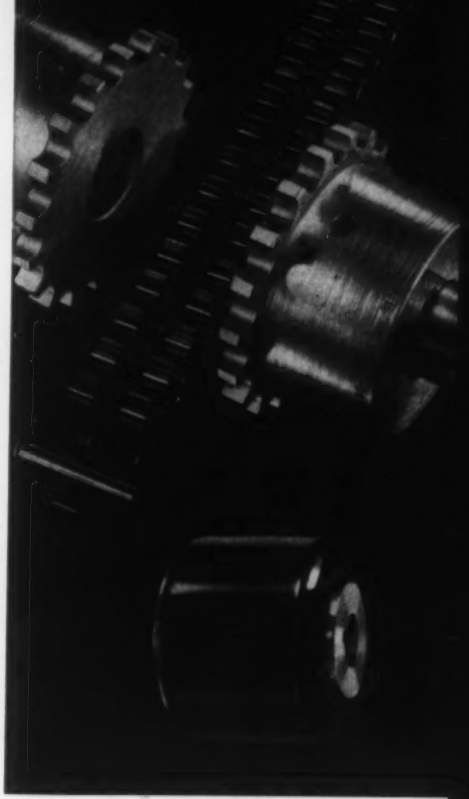
Tantalum Capacitors

solid-electrolyte types have 2.2 to 47 mfd capacitance range

Solid-electrolyte tantalum capacitors are rated at 6, 10, 15, 20, and 35 v. Capacitance range is 2.2 to 47 mfd, and standard tolerance is ±20 per

Another PLUS value...

SPEEDS INSTALLATION



Rex Roller Chain Flexible Couplings are simplicity itself when it comes to installation or removal. Just mount the sprockets on the shafts, wrap the chain around the sprocket teeth, connect it with the single connecting pin. That's all there is to it. No need to make an axial shift of either shaft...no springs, discs or other complicated parts. Are you getting the most for your coupling dollar? For the facts, mail the coupon.

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Circle 563 on Page 19

Music and fun in the children's ward —on Junior Red Cross Visiting Day.

One "Youth Gang" we need more of...

Rock 'n rollers? That's right. *Rock 'n rollers in a children's hospital.*

The three "gang members" are Junior Red Cross members who've taken an afternoon of their time to go to the hospital and entertain some little crippled kids. Reassuring, isn't it?

They do things like this all the time. Regularly. Girls and boys.

20 million of our sons and daughters make up Junior Red Cross—the largest youth organization in the country. Junior members take part in every one of the Red Cross service programs that young people can help to carry on.

When disasters hit, Junior Red Cross volunteers help in many ways—as messengers, typists, canteen workers, information clerks. Many Junior Red Cross members have served with real distinction in disaster emergencies.

Through the Gift Box Program in their schools, Juniors send relief supplies to children overseas. Like all Junior Red Cross activities, this program is financed entirely by the Juniors themselves.

Friendship between children all over the world is fostered by the Junior Red Cross correspondence-album and art programs.

Junior Red Cross is at work every day, helping to build a strong, decent, responsible young America.

These are kids we don't have to worry about. Let's be sure they know they can depend on *us.*

Join

On the job when you need it most

cent. Capacitors are hermetically sealed and meet applicable military specifications. Temperature range is −55 to +85 C. Low dc leakage current does not exceed 0.04 ma per mfd-v or 2 ma, whichever is greater. **Magnavox Co.**, Dept. NP, 2131 Bueter Rd., Ft. Wayne, Ind. J

Circle 751 on Page 19

Socket Cap Screws

are completely cold forged

Flat-head screws speed assembly, offer close fit, and have good

holding power. They are completely cold forged, which compresses and densifies steel structure. Screws have deep sockets with hex running to bottom of socket and free of chips. Sides of head come to a sharp, even edge at top, with uniform taper. **Brighton Screw & Mfg. Co.**, 1841 Reading Rd., Cincinnati, Ohio. G

Circle 752 on Page 19

Silicon Rectifiers

are diffused-junction types

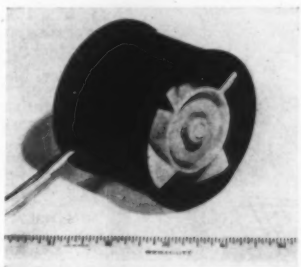
No. 1N1763 and 1N1764 low-cost rectifiers are enclosed in a metal envelope having welded hermetic seals. The diffused-junction units are for use in power supplies of television receivers, radio receivers, phonographs, and other electronic equipment. The 1N1763 has a peak inverse voltage rating of 400 v, dc forward current rating of 500 ma, and maximum reverse current of 100 ma at rated peak inverse voltage and ambient temperature of 25 C. It is intended for rectifier applications in which device operates directly from a power line at ac secondary voltages to 140 v. No. 1N1764 has maximum peak inverse voltage rating of 500 v and is for rectifier applications in which device operates from power line through step-up transformer at ac secondary voltages to 175 v. Rectifiers operate at ambient temperatures to 100 C. **Semiconductor Div., Radio Corp. of America**, Somerville, N. J. D

Circle 753 on Page 19

Axial Blower

delivers up to 169 cfm

High-efficiency blower meets appropriate MIL specifications. It operates at 115 or 200 v ac, 400 cycles, three-phase. Unit delivers up to 169 cfm, and can deliver 100 cfm against static pressure of 3.5 in. H_2O. Housing and propeller are precision cast of aluminum. Power input at peak air volume is 120 w. Unit is 2⅜ in. long by 2.812 in. diam with 3-in. servo ring attached, and weighs 14 oz. It can be mounted by clamp to servo flanges, by



OD clamp, and by use of a special flange. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 754 on Page 19

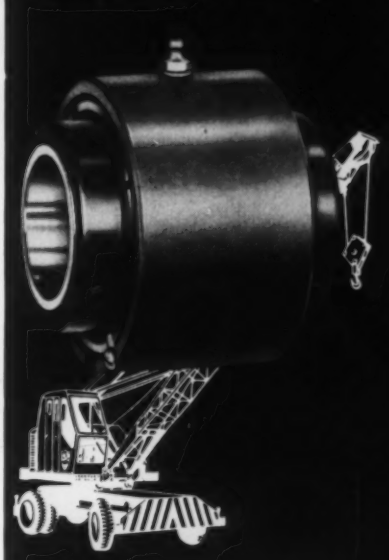
Hydraulic Motor

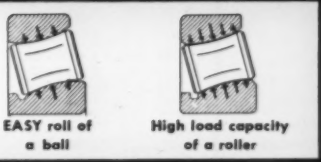
can be used as a pump in closed hydraulic circuit

Hydraulic motor, designed primarily to drive a fuel booster pump, can also be used as a pump in a closed hydraulic circuit. Over-all efficiency remains the same whether unit is operated as a pump or motor. With 7.3-gpm flow, motor develops 11 hp at 4400 rpm with 300 psi differen-

Another PLUS value...

BUILT TO TAKE IT... EASY





Here's why Shafer Bearings add extra stamina and life to heavy-duty equipment. Combining the low rolling friction of a ball with the high load-carrying capacity of a roller, they roll easily, yet take more of the most punishing loads and shocks. Shafer Bearings take radial, thrust or combined loads and misalignment without binding, without loss of load capacity. Write for latest catalog.

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Circle 564 on Page 19

DESIGNS THAT WORK Best START WITH SYNCHRON® TIMING MOTORS

Precision-engineered SYNCHRON synchronous motors operate smoothly, efficiently in any position at temperatures from —40°F to + 140°F . . . start instantly under load . . . pull up to 20 in. oz. at 1 r.p.m. Speeds from 0.8 r.p.m. to 600 r.p.m.

UL and CSA approvals

BUILT FOR PERFORMANCE

1 PATENTED TWO-PIECE FIELD STRUCTURE

2 DOUBLE BEARINGS in reduction train

3 ALUMINUM ROTOR RING SUPPORT.

4 PATENTED, HARDENED STEEL ROTOR RING.

5 OIL STORAGE RESERVOIR with patented oil feed to bearings.

6 HEAVY BRASS ROTOR COVER.

7 DOUBLE BEARINGS ON OUTPUT SHAFT.

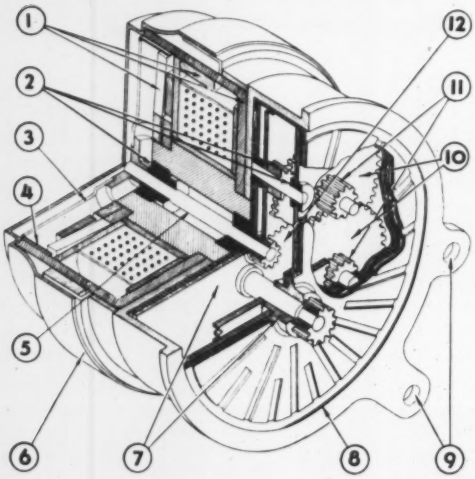
8 GEAR CASE SEALED against oil leakage to permit mounting in any position.

9 FOUR CONVENIENT MOUNTING HOLES.

10 BRASS GEARS.

11 STEEL PINIONS.

12 BAKELITE GEAR for quiet operation.



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STANDARD TIMING MOTOR (8 IN. OZ.)
Compactly built to space saving dimensions, with rotor and coil packed in a sturdy hand-sized case. Used in timing devices and controls of all types. Guaranteed torque 8 in. oz. at 1 r.p.m.

HI-TORQUE TIMING MOTOR (20 IN. OZ.)
There's big power packed into this versatile timing motor. One year guarantee. Dependable, accurate, trouble-free. Guaranteed torque 20 in. oz. at 1 r.p.m.

SLO-MOTION TIMING MOTOR
Versatile new pear-shape timing motor developed especially for replacement application. 110 speeds available within ½ r.p.h. and 360 r.p.m.

HANSEN CLOCK MOVEMENTS
For standard and office clocks, sign clocks, novel., clocks, and clocks of all kinds up to 26" in diameter under glass. Precision power with a Synchron timing motor.

HANSEN MAGNA-TORC DC MOTOR
Designed for aircraft instruments and radio controls. Armed Forces applications have proved its top performance world-wide under all operating conditions. Easily adapted to commercial uses.

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"Workhorse of the industry"
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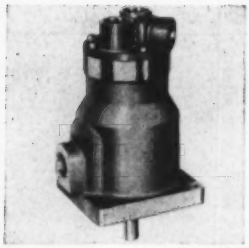


tial, and is operable in fluid temperatures from −65 to 450 F. Motor is high-temperature stainless and tool steel throughout. **Lear-Romec Div., Lear Inc.**, Elyria, Ohio. G

Circle 755 on Page 19

Wire-Wound Resistors

need no derating with new coating

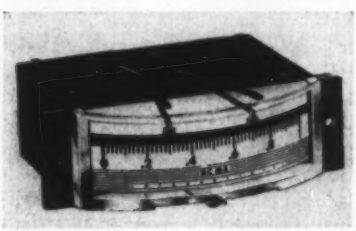
Resisteg coating enables power wire-wound resistors to maintain full rating, even at high resistance values. Ability to use closely spaced turns of heavy wire in the resistors increases transfer of heat from interior of resistor to terminals. This reduces hot-spot temperatures, dissipates sudden overloads more quickly, and keeps resistor cooler, with resulting increased reliability. Resistors will not crack or craze from aging, thermal shock, or internal stress. Coating contains no salts which encourage electrolysis and wire corrosion. **International Resistance Co.**, 401 N. Broad St., Philadelphia 8, Pa. E

Circle 756 on Page 19

Control Meter

miniature unit operates without contacts

Model 2545 miniaturized control meter has applications in automatic control systems, alarm and warning circuits, and in level indication. Unit operates without use of contacts at set points, permitting full-scale range of meter to be available for readings at all times. Control set arms are adjustable over 80 per cent of scale area from front of instrument. Meter circuit and control circuit are separate and electrically isolated. Meter can be supplied for horizontal mounting. Scale length is 2.7 in., and panel area is only 5.5 sq in. Accuracy is held to ±2 per cent of full-scale deflection. **International Instruments Inc.**, P. O. Box 2954, New Haven, Conn. B

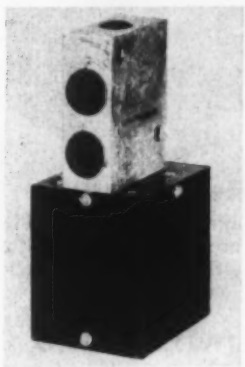


Circle 757 on Page 19

Solenoid Valves

for pressures to 3000 psi

Two and three-way solenoid valves are available in 1/4, 3/8, and 3/4 in. NPT for ac or dc voltage for pressures to 3000 psi. Poppet construction of two-way valves assures



leaktight sealing when closed. Hardened and ground steel working parts in aluminum housing insure durability. **Fluid Power Accessories Inc.**, 2051 Railroad Ave., Glenview, Ill. J

Circle 758 on Page 19

Appliance Switch

has minimum of 0.2 in. overtravel

No. 6PL41 appliance switch can be mounted from side or through a panel. Special plunger mechanism provides minimum of 0.2 in. overtravel without curtailing switch life. Median mechanical life is over 2 million operations at full overtravel. One of two 0.145-in. diam mounting holes is elongated to 0.175 in. to eliminate necessity for close tolerance in locating mounting holes on equipment. Contact arrangement is single-pole, double-throw. Switch can be wired normally open or normally closed and is electrically

Another PLUS value...

BUILT TO TAKE

VIBRATION

Even under car-shaker vibration that loosens tons of coal, Shafer Bearings keep their steel grip on longer life

This reserve stamina stems from exclusive bearing design and precision construction. Concave rollers matched to convex raceways are of highly elastic, case-hardened alloy steel. With every shock, rollers compress, increasing bearing surfaces.

Even under misalignment, Shafer Bearings roll safely with the punch. Mail the coupon.

SHAFER®

SELF-ALIGNING ROLLER BEARINGS

CHAIN Belt Company 511-A
4643 W. Greenfield Ave.
Milwaukee 1, Wisconsin
(In Canada, CHAIN Belt Canada Ltd., 1181 Sheppard Ave. East, Toronto)
☐ Please send Shafer Bearing Catalog 59A.
☐ Have a Shafer Man call.

Name.....
Company.....
Address.....
City.....Zone....State.....

Circle 566 on Page 19

Stearns electro-magnetic

miniature CLUTCHES

STYLE "SM"*

Now Available in 6 Standard Sizes

* Stationary Magnet

Installation-Proved Reliability . . .

Users' expressed satisfaction on the long life and maintenance-free operation of the thousands of SM's in use on their applications confirms the advantages of the heavy-duty design and construction features of these units.

Wide Range of Size and Torque . . .

Six Sizes (shown above) — 7/8, 1 1/8, 1 13/16, 2 1/8, 2 5/8, 4 1/4 in. square. Max. Torques Range from 25 oz in. to 240 lb in.

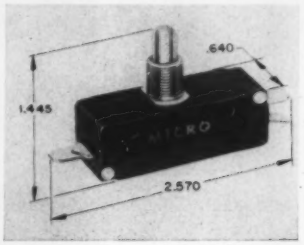
✓ Check—Compare these $aving Advantages:

1. Heavy-Duty Construction for long, trouble-free life. Heavy-gauge frame resists distortion. Solid-type, low-carbon "Armco" steel armature for greater strength and longer wear. Solid, molded, fully finished metallic and asbestos friction element for longer, efficient life than a thin cemented facing. All wear elements can be quickly, easily replaced, if required, at low cost.
2. Fast, Easy Installation . . . stationary field with flange-type mounting. Most sizes available with option of extended, ball-bearing-mounted driven hubs for integral sheave or pulley mounting.
3. Self-Adjusting.
4. No slip-rings or brushes to install or maintain. Furnished standard with 12-in. to 14-in. wire leads. Terminal block or plug-in connections are optional.
5. Moisture-, Corrosion-Resistant . . . coil is embedded in an epoxy resin compound—not merely coated. All metal parts finished with a chromate-converted zinc plating.
6. Fast, Positive Actuation.
7. Assures accurate, dependable, power or motion control energized by any adequate switching device.

For Superior Performance—Reliability . . . Specify Stearns!

Contact your local Stearns Representative for complete data and information on how to obtain prototype units for your specific installation. Or write direct, stating specific application information. Request Bulletin No. 504-BF.

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN



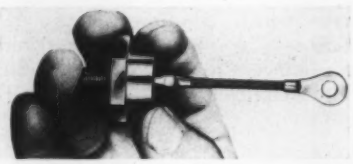
rated for 15 amp, 125 or 250 v ac. **Micro Switch Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill. K

Circle 759 on Page 19

Silicon Rectifiers

for intermediate power applications

SN-60 ac to dc power rectifiers have excellent electrical and mechanical characteristics. They are designed for intermediate power applications. Maximum forward voltage drop is only 1.2 v at 10 amp, 27 C. Diodes are hermetically sealed to withstand severe service without failure. Elimination of fluxes and other coatings from welding process insures clean, uncontaminated junction which will not deteriorate with age.



Thermal efficiency is very good. Small size enables installation in minimum space. Diodes are available with flat or stud bases, and with flexible or rigid positive connections. **Syntron Co.**, 260 Lexington Ave., Homer City, Pa. F

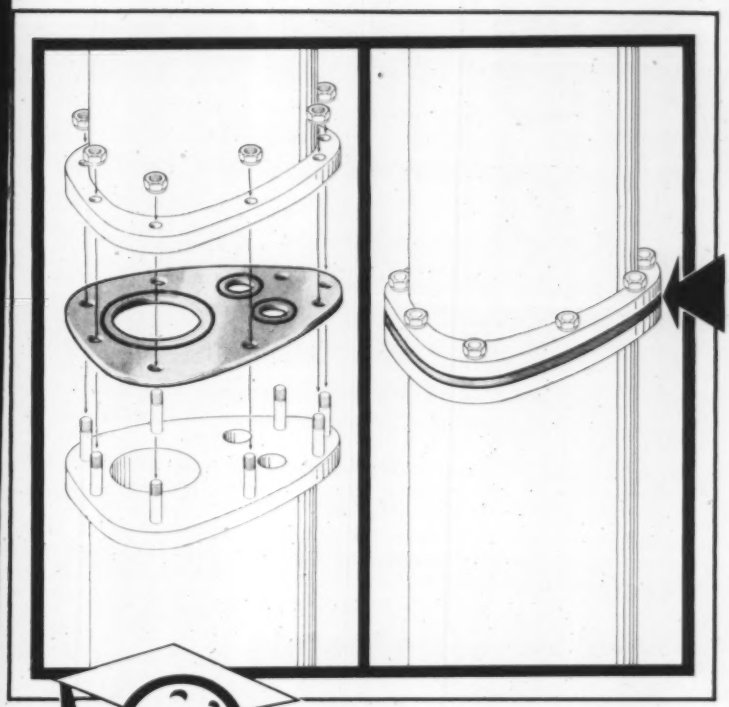
Circle 760 on Page 19

Vertical-Shaft Engines

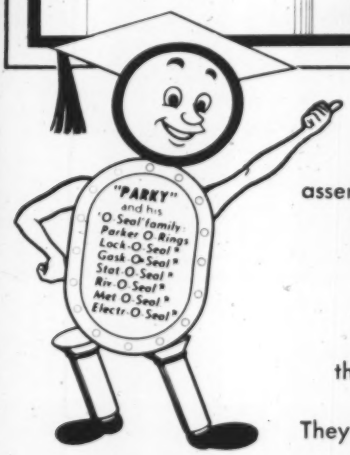
for heavy-duty uses

Model HACN vertical-shaft engine has a power range from 2.5 to 6 hp at 1600 to 3600 rpm. Model HBKN has a range from 3.5 to 7 hp in 1600 to 3600 rpm speed range. Engines are designed for compact, low-silhouette applications. Features include: tapered-roller main bearings; forged aluminum connecting rod; counterbal-

DO YOU KNOW ABOUT GASK-O-SEALS?

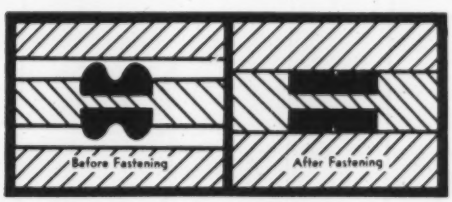


You Can't leave a Gask-O-Seal® out!



Hundreds of accidents have been caused by seals being left out during assembly or repair, and thousands of production hours have also been lost for the same reason. Just one of the plus values of Gask-O-Seals is that they are practically impossible to leave out because they are inspectable visually after assembly. This can mean many valuable warranty dollars saved, many hours of downtime saved — and it may mean the saving of human lives.

They also provide no-leakage positive sealing, prevent blow-outs. Damaging coldflow is eliminated, high manufacturing and maintenance machining costs are avoided and they are reuseable. If you use static seals in your designs, why not find out about Gask-O-Seals — made by the makers of Parker O-rings.



Parker SEAL COMPANY

CULVER CITY, CALIFORNIA and CLEVELAND, OHIO

A DIVISION OF PARKER-HANNIFIN CORPORATION

Circle 568 on Page 19

Foundry Engineering aids product development!

This steel casting is another example of Unitcast's ability to cope with unusual problems. As the main body of a new-type Pulsation Dampener for The National Supply Company's oil field equipment, this casting had many tough end-use requirements. Basically, the part had to absorb shock, withstand corrosion, and hold hydrostatic test pressures up to 8,000 psi. The fewer the components in the part, the better the durability.

The ideal solution, a one-piece steel casting, required accurate suspension of a huge core on a minimum number of points to produce a horizontal "tank" within consistent tolerances. One subsequent finishing problem involved economically "sealing" the core suspension holes by a method that would hold up in end use—*plus* pass radiographic inspection!

Once again, Unitcast foundry engineering has helped a customer develop a new product for their well-known line. Why not call in Unitcast engineers on your product-development problems? Write today!

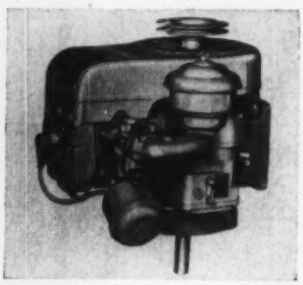
UNITCAST CORPORATION, Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

anced, heat-treated, drop-forged crankshaft; removable aluminum cylinder head; replaceable valve-stem guides. Positive lubrication is supplied by vane-type oil pump which furnishes spray in crankcase to lubricate all internal engine parts. Ignition is supplied by a dust and weather-sealed, outside-mount-



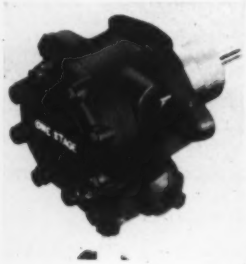
ed, high-tension magneto with impulse coupling. Built-in mechanical flyball governor provides close speed regulation. Large fan cast in flywheel provides proper cooling at temperatures to 140 F. **Wisconsin Motor Corp.**, 1910 S. 53rd St., Milwaukee 46, Wis. K

Circle 761 on Page 19

Gear-Type Pumps

for pressures from 10-300 psi

Series Q7 pumps for lubricating or hydraulic oils are available for either left or right-hand shaft rotation. Four capacities range from 38 to 41 gph at 1200 rpm, and from 57 to 62 gph at 1800 rpm. Gear-type units operate at pressures from 20 to 300 psi and speeds of 1200-1800 rpm. Small inner roller, keyed to shaft, drives outer member at speeds 25 per cent below motor speed, assuring quiet operation and long pump life. Pumps are supplied with positive-acting, piston-type relief valve in 20-40, 40-80, 80-150, or 150-300 psi pressure ranges. Positive pumping action



Circle 570 on Page 19

MESSINGER GEAR BEARINGS

Two Extremes **in Gear Bearings . . . each designed and built for a specific application. Which do you need?**

"FEATHERWEIGHT"

BALL BEARING—EXTERNAL GEAR
11.999" I.D. x 14.562" O.D. x .635" WIDE

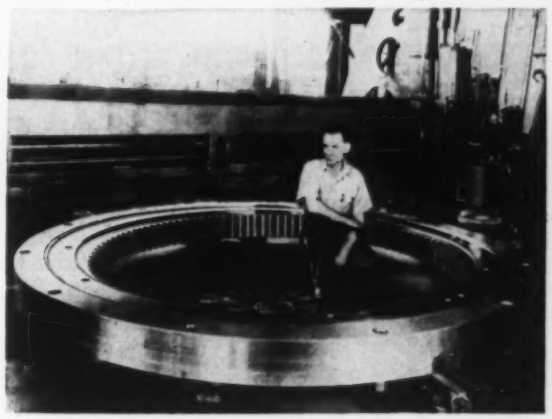
464 TEETH—32 D.P.
14.50" PITCH DIAMETER

STATIC CAPACITY:

RADIAL—9,420 LBS.
THRUST—3,287 LBS.
MOMENT—10,760 IN. LBS.

"HEAVYWEIGHT"

"X" ROLLER BEARING—INTERNAL GEAR
ORIGINALLY BUILT IN 1943
80.812" I.D. x 107.50" O.D. x 7.00" WIDE



122 TEETH—1.50 D.P.
81.33" PITCH DIAMETER

STATIC CAPACITY:

RADIAL—582,821 LBS.
THRUST (One Direction)—2,547,000 LBS.
THRUST (Opposite Direction)—1,273,500 LBS.
MOMENT—27,975,000 IN. LBS.

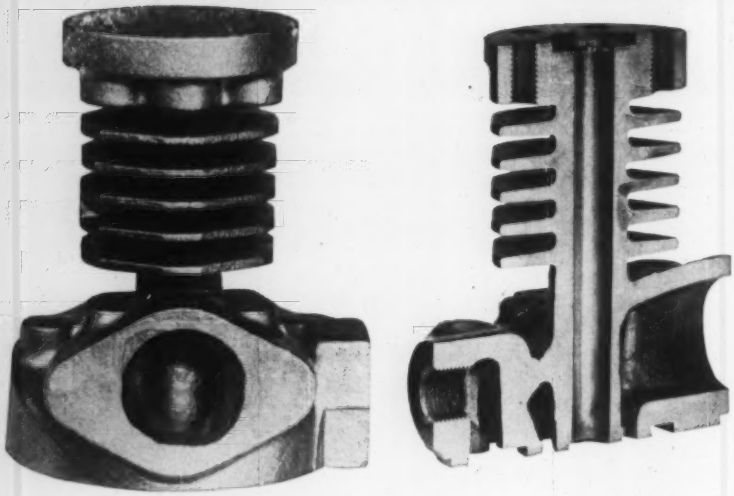
NOW PRODUCING GEAR BEARINGS OF 160.50" O.D.

Smoothing Industry's Pathway ...*for Nearly Half a Century*

MESSINGER BEARINGS, INC.

D STREET ABOVE ERIE AVENUE, PHILADELPHIA 24, PENNA.

BALL AND ROLLER BEARINGS • FEATHERWEIGHT TO HEAVYWEIGHT



PRESSURE TIGHT

A CASE IN POINT—This 8 pound Meehanite Metal casting made for the Joy Manufacturing Co. by Hamilton Foundry is a fourth stage air compressor cylinder. Pressures build up to 6,000 p.s.i. and require a high strength, pressure tight and wear resisting casting. Alloyed Meehanite® oil quenched and tempered, raised Brinell hardness of the cylinder wall to 275-300, and increased tensile strength to 60,000 p.s.i. Meehanite was chosen for this casting because controlled structure and small uniform flake graphite produce pressure tight castings of uniform density and strength.

Meehanite is both an iron—and a controlled process. Through the Meehanite Process the microstructure and the quantity and form of graphite is consistently controlled. This means that a specific type of Meehanite can be selected to meet engineered casting requirements. Testing of every ladle of molten iron insures that specifications will be met in the casting.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY

The Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio • TW 5-7491

produces a vacuum of up to 25 in. Hg maximum. **Hydraulic Div., Sundstrand Machine Tool Co.,** 2210 Harrison Ave., Rockford, Ill. K

Circle 762 on Page 19

Tachometer-Generator

miniature unit is rated for continuous operation at 350 F

Miniature tachometer-generator, a two-pole, three-phase unit, is available for use in jet aircraft. Weight

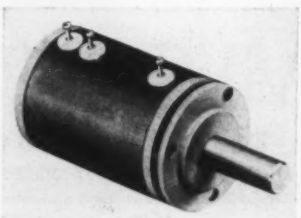
has been reduced from 26 to 12 oz, with comparable size decrease. Generator is rated for continuous operation at 350 F. **General Electric Co.,** Schenectady 5, N. Y. C

Circle 763 on Page 19

Multiturn Potentiometer

withstands temperatures of 200 C

Model 590 all-metal precision potentiometer is available in ranges from 25 to 120,000 ohms. Standard linearity tolerance is ±0.3 per cent, with tolerances to ±0.025 per cent available on special order. Unit withstands temperatures from −65 to 200 C. Potentiometer is machined aluminum with helical coil directly against case for maximum heat dissipation. Fused-glass sealed terminals are flashed with precious metal. The 1-in. diam unit functions above 20 g vibration from 55 to 2000 cps, withstands 30-deg shock, and meets all specifications to 30,000 ft. Up to 45 extra



Circle 572 on Page 19

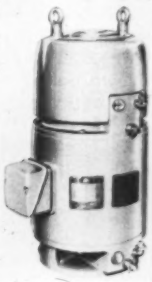
terminals can be added to three standard terminals to meet special requirements. **Spectrol Electronics Corp.**, 1704 S. Del Mar Ave., San Gabriel, Calif. M

Circle 764 on Page 19

Vertical Motors

hollow-shaft units resist moisture and contaminants

All-weather motors which provide indoor and unprotected outdoor service are available in 1 to 30-hp ratings. Vertical, hollow-shaft units resist moisture and chemical contaminants, and have high mechanical strength. Oil-metering system, sealed bearing chambers, and magnet drain plugs provide bearing protection. Minimum of cooling air is required, permitting low cooling air velocity and preventing dust and moisture from being drawn into motor by air stream. Self-release couplings prevent unscrewing of shafting



in case of accidental motor reversal. **Louis Allis Co.**, Dept. P, 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 765 on Page 19

Servo Valve

operates at supply pressures as low as 50 psi

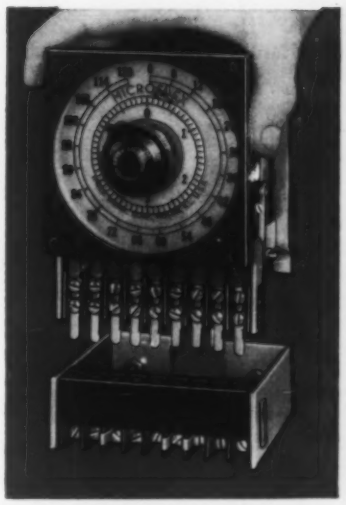
Model 200 servo valve is a single-stage, four-way, flow-control unit designed for use in electrohydraulic servo systems where reliability and ruggedness are important. It features a powerful dc torque motor, capable of exerting over 13 lb force, for valve actuator. Motor exerts full force when particle-jamming or silting conditions are encountered, enabling valve to operate reliably in relatively contaminated fluids. Rotary-plate valving principle provides zero lap condition. Unit operates at

Savings
- Large 15 ampere contacts eliminate additional load relays.
- Stop down time with plug-in components for fast timer replacement.

Flexibility
- Easy to set dial whether short or long timing.
- Choice of 9 actions available for each of 3 contacts. Select operation required for your circuit.

Accuracy
- Set dial to exact time required. No guessing at numbers.
- Accurate repeatability insures uniform production.

Reliability
- Proven reliability in thousands of industrial processes for more than 25 years.



Install timer in seconds with optional plug-in feature.

EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. MD-359
MOLINE, ILLINOIS

Please send FREE Bulletin 110 containing complete data on Microflex Reset Timers.

NAME AND TITLE

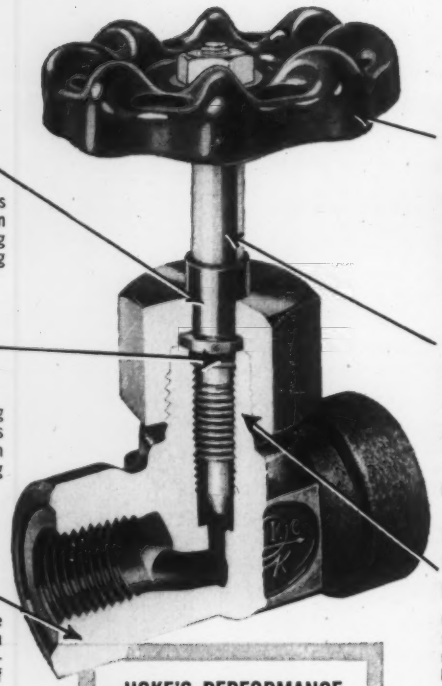
COMPANY

ADDRESS

CITY ZONE STATE

Circle 573 on Page 19

LOW COST FLUID CONTROL at HIGH PRESSURES (and low, too)



EXCLUSIVE NYLON STEM WIPER
Positively prevents foreign matter from scratching or pitting stem, harming O-ring seal.

GUARANTEED LEAK-PROOF O-RING SEAL
Forget about packing adjustments, leaks through stem with tough, pliable O-ring seal.

FORGED CARBON STEEL BODY
Heavy duty, weldable carbon steel body in globe or angle patterns, selection of male or female connections.

DIE-CAST ALUMINUM HANDWHEEL
Easy grip, non-slip, die-cast handwheel gives you smooth turning down for quick, accurate flow control.

CENTERLESS GROUND STEM
Stainless steel, centerless ground stem assures perfect fit, positive shut-off.

SAFE, INTEGRAL BONNET
One-piece, forged steel body and bonnet insures against blow-out, gives added measure of safety.

HOKE'S PERFORMANCE GUARANTEE —
Every Valve Leak-Tested!

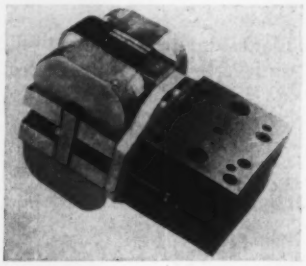
SERIES 100 FORGED NEEDLE VALVES

FREE: A sample valve is yours for the asking. Put this heavy duty, versatile valve to the test on hydraulic lines, manifolds, air lines, test stands. Use it for regulating or shut-off of water, oil, gas. Temperature range —40 to 200°F. Pressure rating; vacuum to 10,000 psi. Write to us on your company letterhead for the full story and your FREE SAMPLE VALVE.

See Our Catalog in Sweet's Product Designer's File

HOKE

HOKE INCORPORATED
Fluid Control Specialists
91 PIERMONT RD., CRESSKILL, N.J.



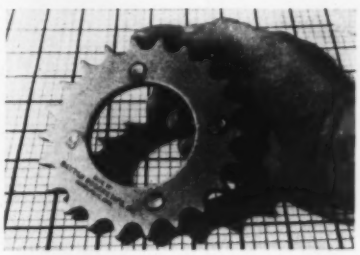
supply pressures from 50 to 1000 psi. Operating temperature range is −65 to 265 F. Valve measures 2¼ x 2½ x 3½ in. and weighs 42 oz. **American Measurement & Control Inc.**, 240 Calvary St., Waltham 54, Mass. B

Circle 766 on Page 19

Plate Sprockets

are bored to fit specific requirements

Roller-chain plate sprockets are die-cut and have custom-made bore sizes to fit individual requirements. They are ready for installation and require no reworking. Sprockets are furnished to ASA standards, with or without rustproofing. They are also furnished with hardened teeth



if required. **Dayton Rogers Mfg. Co.**, 2830 S. 13th Ave., Minneapolis 7, Minn. J

Circle 767 on Page 19

Laminated Plastic

is primarily for printed-circuit uses

Phenolite XXXP-475 flame-resistant laminated plastic offers excellent electrical properties, high insulation resistance, and low moisture absorption. It exceeds all NEMA required values for grade XXXP, and yields excellent punching results with minimum of heating in temperature range of 130 to 150 F. Applications include com-

puters, aircraft equipment, telephone equipment, television and radio sets. Grade is offered both as a standard laminated plastic and in copper-clad form for printed-circuit bases. A paper-base type, it is laminated with modified phenolic resin which provides flame resistance. Thicknesses range from 1/32 to ¼ in., and sheet sizes are 39 x 47 in. and 39 in. square. **National Vulcanized Fibre Co.**, 1059 Beech St., Wilmington 99, Del. C

Circle 768 on Page 19

Pipe-Thread Adaptors

of stainless steel in ⅛ to ½-in. sizes

Available stainless-steel adapters include connector, reducing connector, thread reducer, nipple, elbow, 45 and 90-deg street elbows, tee, and cross. They are precision machined from Type 316 stainless with Dryseal threads. Size range is from ⅛ through ½-in. pipe thread. **Parker Fittings & Hose Div., Parker-Hannifin Corp.**, 17325 Euclid Ave., Cleveland 12, Ohio. F

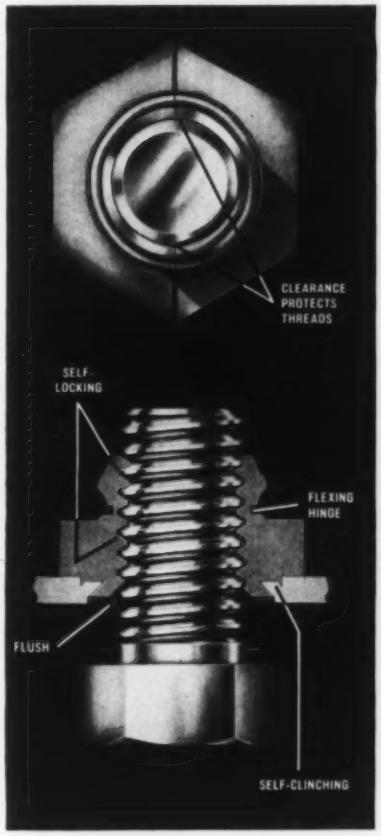
Circle 769 on Page 19

Circuit Breaker

for aircraft and missile ground-support equipment

Klixon D6760-5 thermal-type, three-phase circuit breaker is suitable for use on 220/440-v ac systems operating at 60 or 400 cps. Electrical ratings are 5 to 60 amp. Model handles short circuit between 800 and 1000 amp at 440 v. It is designed for applications on aircraft and missile ground-support equipment where high-voltage power is used. Unit weighs about 8 oz. It has simultaneous tripping of all three phases with an overload in any one or more phases. Single button opens and recloses all three phases. Break-

Tops in Performance...



ALL-METAL SELF-LOCKING SELF-CLINCHING PEM NUTS

Combine two essential functions in one lightweight, low-cost unit.

The self-clinching feature is the same tried and proven original PEM design, recognized by industry as the answer to production fastening. It is installed by a squeeze into sheet metal, too thin to thread, by standard pneumatic, hydraulic or mechanical presses.

The all-metal, self-locking feature offers distinct lock-nut design improvements required for top performance under temperature, vibration and stress requirements of such high-reliability services as missile, rocket, aircraft and electronic components.

Exclusive Design • Outstanding Advantages

The All-Metal, Self-Locking features of the new PEM Nut speak for themselves:

ONE SLOT design: two rugged semi-circular jaws with inherent flexing action—far stronger than several less-supported segments.

FLEXING HINGE: a machined slot at the base of each semi-circular jaw retains inherent flexing action, permanently. Guarantees against relaxation and loosening in severe service. Permits reuse, repeatedly, without diminishing self-locking efficiency.

PROTECTS THREADS: fewer segments—plus relief of cutting edges of single slot design, to provide clearance, insures that *no* cutting edges come in contact with the screw.

Made in #303 stainless steel (temperatures to 800° F); steel (temperatures to 500° F); high strength aluminum alloy (temperatures to 250° F); in sizes from #4-40 to #10-32 for use in aluminum, brass, copper, and cold-rolled steel sheets of thicknesses from .040 up and stainless steel sheets from .050 up.

Write for literature and sample for test.

• See Our Exhibit • Booth 4515 • Radio Engineering Show • New York Coliseum • March 23 to 26

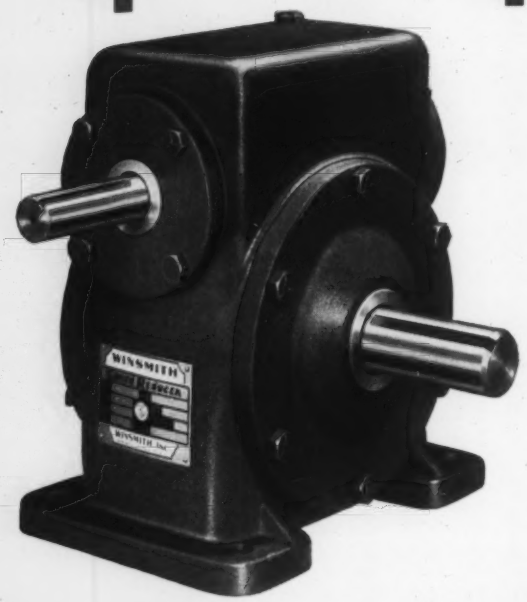
PENN ENGINEERING & MANUFACTURING CORP.

Doylestown, Pennsylvania

Belle Harbor, L.I., N.Y.... Neptune 4-7103; Cincinnati... Humbolt 1-4261; Forest Park, Ill.... Forest 6-4971; Los Angeles... Bradshaw 2-8097; Indianapolis... Clifford 1-4020; Milwaukee... Bluemound 8-6118

Circle 575 on Page 19

all the way
up to 34 hp!



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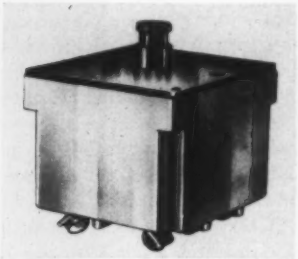
Circle 576 on Page 19



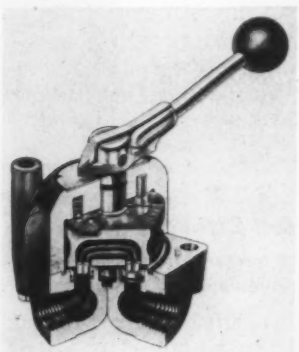
er trips in 2 to 6 millisec on short-circuit interruption. Unit meets requirements of MIL-C-5809. **Spencer Thermostat Div., Metals & Controls Corp.**, Attleboro, Mass. B

Circle 770 on Page 19

Manual Valve

for 3000-psi oil systems

Low-cost, four-way manual valve is lightweight and can withstand proof pressures of 4500 psi and instantaneous surges of 9000 psi. The Series 6140 valve is for use in oil systems with pressures to 3000 psi. Moving parts (detent disc, ball, and stops), are incorporated internally so that they are constantly lubricated by flow of hydraulic oil. Threaded bosses are an integral part of valve housing. Valve is leakproof and not sensitive to grit and dirt. Port sizes range from 1/4



to 1 in. NPT with rated flow from 7 to 38 gpm. Valve is high-tensile, heat-treated aluminum. **Barksdale Valves**, 5125 Alcoa Ave., Los Angeles 58, Calif. L

Circle 771 on Page 19

Two-Pole Relay

for general-purpose use

Type FC relay is designed for commercial applications where low cost

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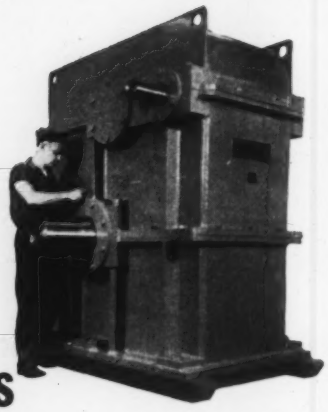

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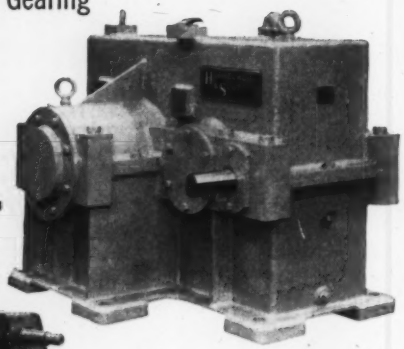

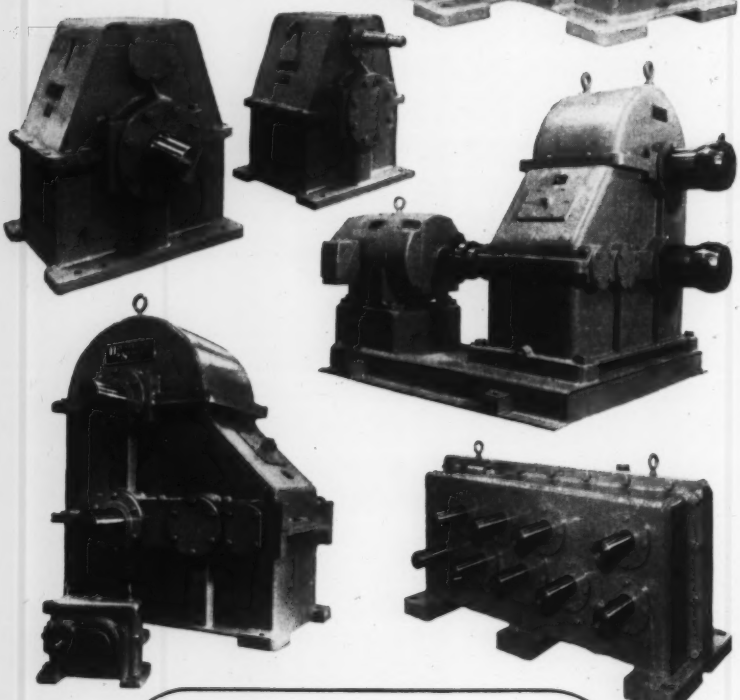

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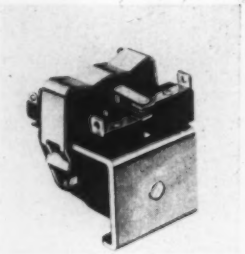


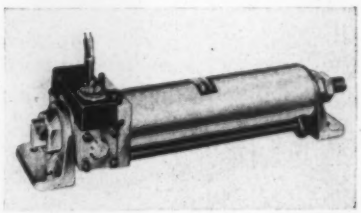
and maximum performance are important. The two-pole unit has silver contacts riveted to a molded panel. It is rated at 2 amp resistive at 26.5 v dc or 115 v ac. Used as a single-pole, single-throw relay, the unit can operate as low as 200 mw. As a double-pole, single-throw relay, it can operate up to 2 w. Coils are available for operation up to 115 v dc. **Allied Control Co.**, 2 East End Ave., New York 21, N. Y. D

Circle 772 on Page 19

Air Cylinders

in 1½, 2, and 3-in. bore sizes

Designed for industrial applications where space, weight, and simplified installation are important factors, VIH series air cylinders have built-in directional and exhaust speed-control valves. Cylinders are available in 1½, 2, and 3-in. bore sizes in any stroke length. Directional-control valve actuation can be solenoid, remote pilot pressure, button-



bleeder, or combination solenoid-button bleeder. Independent exhaust speed controls with automatic nylon lock are built in. **Modernair Corp.**, 400 Preda St., San Leandro, Calif. M

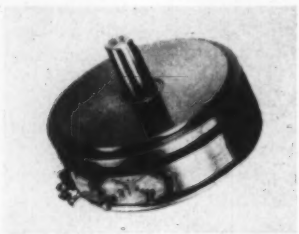
Circle 773 on Page 19

Single-Turn Potentiometer

has standard power rating of 6 w at 40 C

Series 5500, 1¾-in., single-turn, all-metal potentiometer provides stand-

ard resistances from 85 to 146,000 ohms, and standard linearity down to ±0.15 per cent. Standard power rating is 6 w at 40 C, derated to 0 at 150 C. Available in a variety of mounting and bearing styles, potentiometer stands up to shaft speeds of 240 rpm. Ball bearings deliver torque of 0.6 oz-in. in standard models, with as little as 0.2 oz-in. available on special order. Requirements of all applicable MIL spec-



ifications are met or exceeded. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif. L

Circle 774 on Page 19

Punching Laminate

combines clean punching and toughness

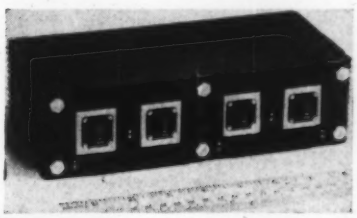
Spauldite 802 laminated thermosetting plastic is recommended where smooth machined or punched edges are required, combined with mechanical toughness in all directions. Material combines clean punching with toughness not possible in paper-base grades. It is available in sheets or fabricated parts. **Spaulding Fibre Co. Inc.**, 310 Wheeler St., Tonawanda, N. Y. N

Circle 775 on Page 19

Transistorized Power Supply

gives three regulated output voltages

P/N 380-100 unit operates at 85 C at full output rating, and is completely transistorized. It supplies



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Circle 579 on Page 19

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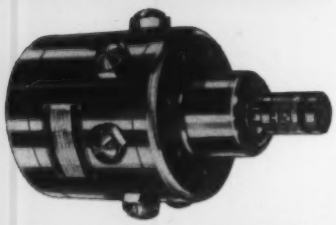

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½ to 20 gpm — up to 10,000 psi.

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2073 Albert Street RACINE, WISCONSIN

Circle 580 on Page 19

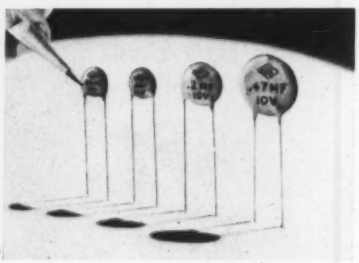
three separate, closely regulated output voltages: 150 v at 630 ma; −150 v at 100 ma; −300 v at 40 ma, for airborne use. Regulation over load and line variation is close, and temperature stability is good. Unit has plug-in installation, with six captivated bolts for mounting. Housing is black anodized aluminum for good heat dissipation, and power transistors are mounted directly on cabinet for good heat transfer. **Master Specialties Co.**, 956 E. 108th St., Los Angeles 59, Calif. L

Circle 776 on Page 19

Ceramic Capacitors

are miniature, 10-v units

Ultra-Kap capacitors have high temperature stability, and hold their capacity over a wide temperature range. Variation in capacity from 10 to 85 C is ±7 per cent. The 10-v units offer over three times the voltage previously available in units of this size. Four capacity values are available: 0.05 mf with 0.385 in. diam; 0.1 mf with 0.385 in. diam; 0.2 mf, 0.590 in. diam; 0.47 mf, 0.840 in. diam. They are available with standard EIA spacing for printed board insertion or random wiring. **Centralab Div., Globe-Union Inc.**, 900 E. Keefe Ave., Milwaukee 1, Wis. K



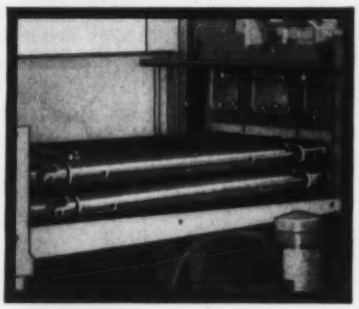
Circle 777 on Page 19

Predetermined Counter

operates at speeds to 1000 impulses per min

Countron unit is available in three models with predetermined selectivity from 1-100, 1-1000, or 1-10,000. Unit handles counting and batching speeds to 1000 impulses per min. It operates under severe conditions of vibration, shock, heat, cold, dust, and humidity. Counter can be

HOW CURTIS SOLVED A CLOSE CENTER-TO-CENTER PROBLEM



The close center-to-center spacing of these drive spindles on a Sutton-Maust Precision Backed-up Roller Leveler created a tough problem for its manufacturer. He needed a universal joint strong enough to stand up under heavy rolling mill conditions, yet small enough to operate at such close quarters.

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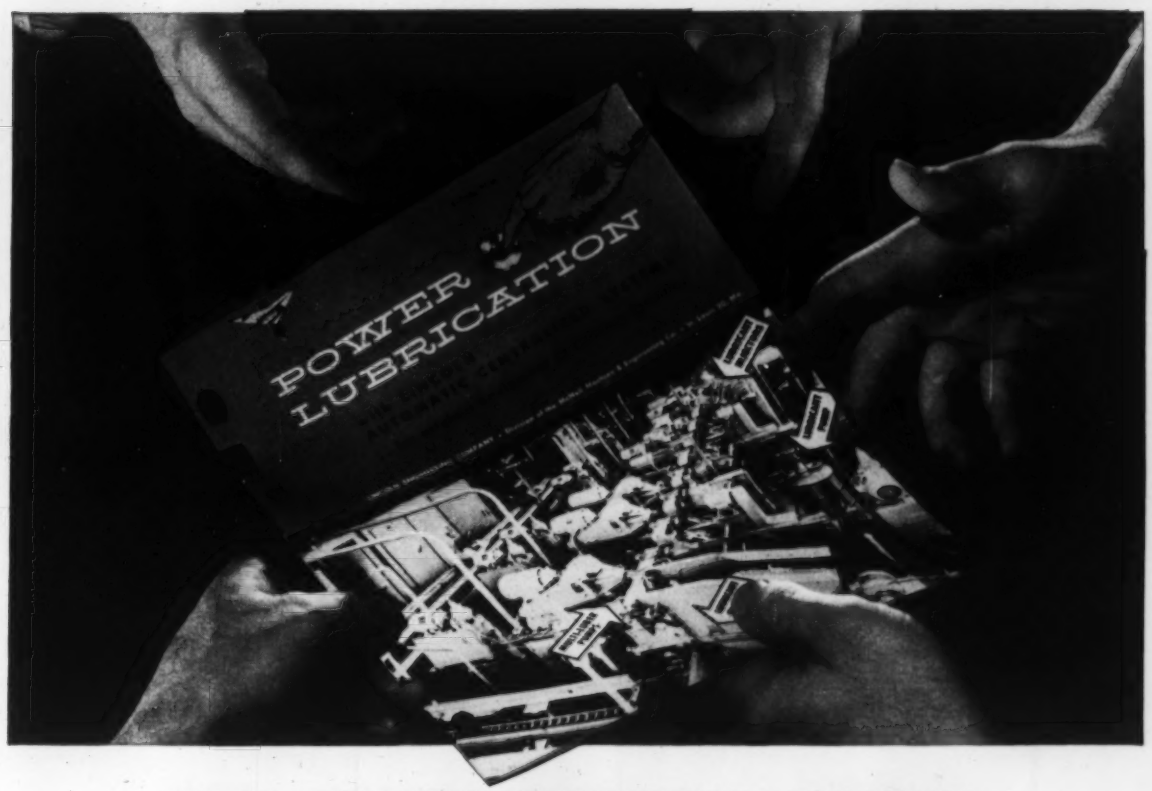

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Circle 582 on Page 19

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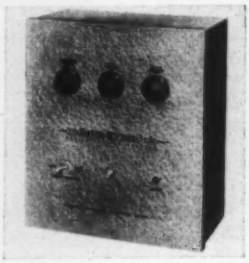


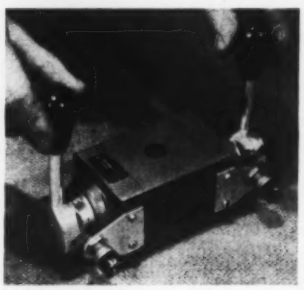
mounted on a wall or machine, or, by removing outer housing, can be panel mounted. Unit automatically recycles to zero after each complete count cycle. **Hobson Miller Machinery Corp.**, 280 LaFayette St., New York, N. Y. D

Circle 778 on Page 19

Double Hydraulic Valve

in 2 to 40 gpm sizes

New valve is available in three and four-way combinations, in sizes from 2 to 40 gpm with detented or spring-return handles. Cem-Lap seals mating with optically flat rotor surfaces assure positive sealing at 2500-psi pressure for oil and 2000 psi for water and gas. Motor starting switches can be added, as shown, for ac or dc operation. Pump then runs only when handle is turned. Valves are suitable for use in ma-



terials-handling equipment, road machinery, and machine-tool applications. **Clark Engineering & Mfg. Co. Inc.**, 1820 Layard Ave., Racine, Wis. K

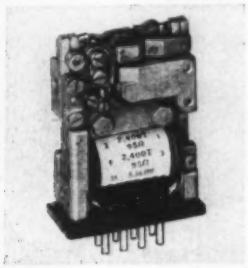
Circle 779 on Page 19

Polarized Relay

in applications requiring impulse repetition

Bistable or center-stable relay is for use in bridge circuits as a null-sensing device without amplifiers, in various military and aircraft instal-

lations, or in any application requiring impluse repetition. Unit produces a square-wave output from weak input signals. Having no contact bounce, relay withstands 4000 shocks at 40 g and vibration from 10 cps at 0.04 in. to 150 cps at 0.006 in., double amplitude. Sensitivity is 1 to 3 amp-turns for Type 51M (center-stable) and 2 to 5 amp-turns for Type 51A (bistable). Thermal stability ranges



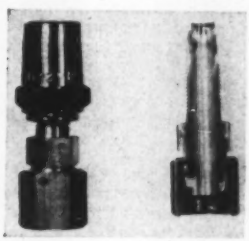
from − 40 to 70 C. Relay weighs only 5.5 oz. **C. P. Clare & Co.**, 3101 Pratt Blvd., Chicago 45, Ill. I

Circle 780 on Page 19

Swivel Fitting

is two-piece unit

H-52 fitting is for use on hose with ID from 3/16 to 3/8 in. and OD from 3/8 to 3/4 in. The swivels are all nickel and chrome plated. Two-piece unit is attached with stainless-steel wire inserted in swivel head,



insuring leakproof and vibration-proof swivel fitting. **Hofmann Engineering Co.**, 4022 W. 55th St., Chicago 32, Ill. J

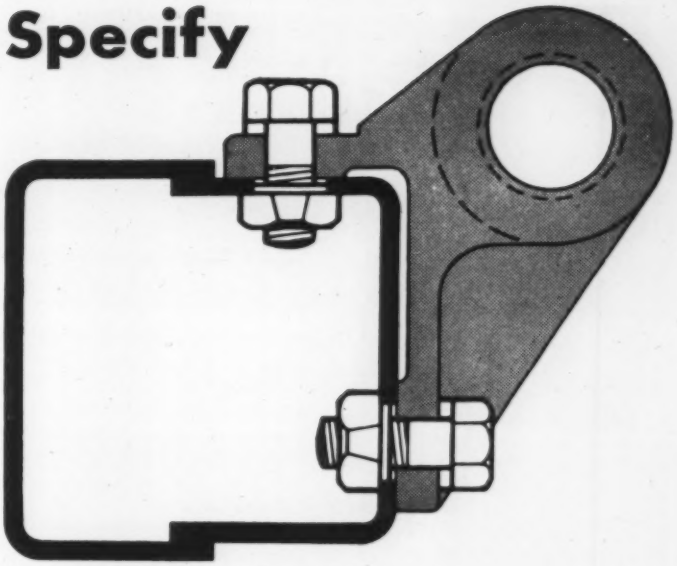
Circle 781 on Page 19

Panel Switches

are available in modules which permit ganging

Digiswitch replaces ten-position octal switch units of rotary type. Panel space requirements permit mounting of 20 switches in space

Specify



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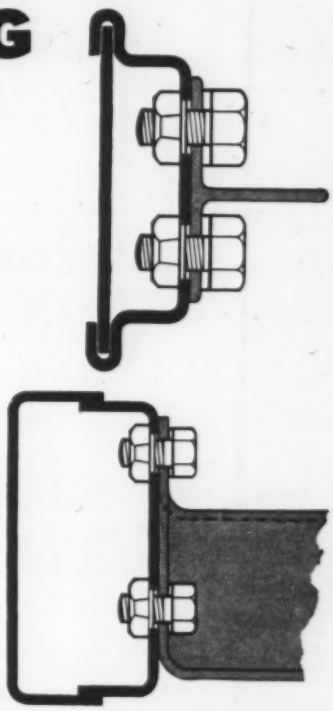

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Circle 584 on Page 19

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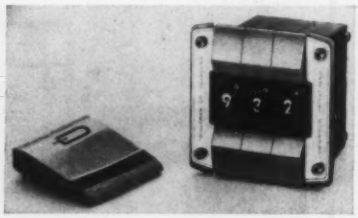
Circle 585 on Page 19



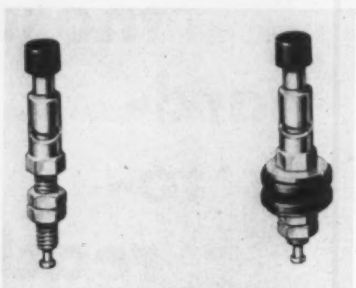
required for five rotary-switch elements. Unit is finger controlled and provides for ten-position, single-pole, binary-coded decimal (1, 2, 4, 8), and octal (1, 2, 4, 7) coded outputs. In-line readout reduces reading errors and simplifies switch setting. Switch is designed in switch modules which permit ganging. Contacts are rated for 200 v, 1 amp, and contact resistance is 0.5 ohm. **Digitran Co.**, 45 W. Union St., Pasadena, Calif. L

Circle 782 on Page 19

Binding Posts

miniature units provide fast, positive contact

Two miniature electronic binding posts are known as No. 29-100, with threaded stud, and No. 29-104, with molded phenolic insulating washers. Designed to provide fast, positive contact, they are operated by depressing plunger, inserting lead, and releasing plunger. Posts



extend only ¾ in. above mounting surface. They are nickel-plated brass with molded phenolic button cap. **Grayhill Inc.**, 561 Hillgrove Ave., La Grange, Ill. I

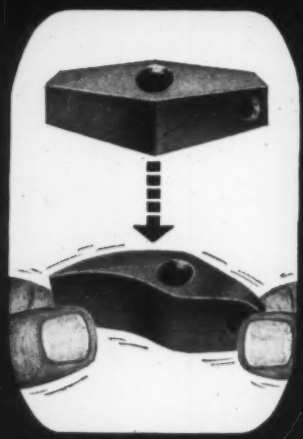
Circle 783 on Page 19

Alternate-Pulse Relay

for use on long production runs

PA alternate-pulse relay has been reduced in size and weight, and is adapted for installation on long pro-

just to *stretch* a point.



. . . Next time specify
INVESTMENT CASTING

Parts design becomes as flexible as wax when you specify Investment Casting. Because with this "lost wax" process, parts can be designed for function; for utmost operating efficiency rather than compromised to satisfy a method of manufacture.

Costly machining and assembly operations are reduced and often eliminated. Complex and time consuming tooling setups too! And — you have the widest selection of alloys from which to choose: the non-ferrous group, the carbon and low alloy steels, the hard-to-form, hard to machine high alloy steels . . . even cobalt base alloys.

Thus you stretch your design potential, you stretch your range of metals and you stretch your budget when you specify this process.

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For complete details, see this new illustrated, informative booklet on the art of Investment Casting. It could be the best investment you ever made.

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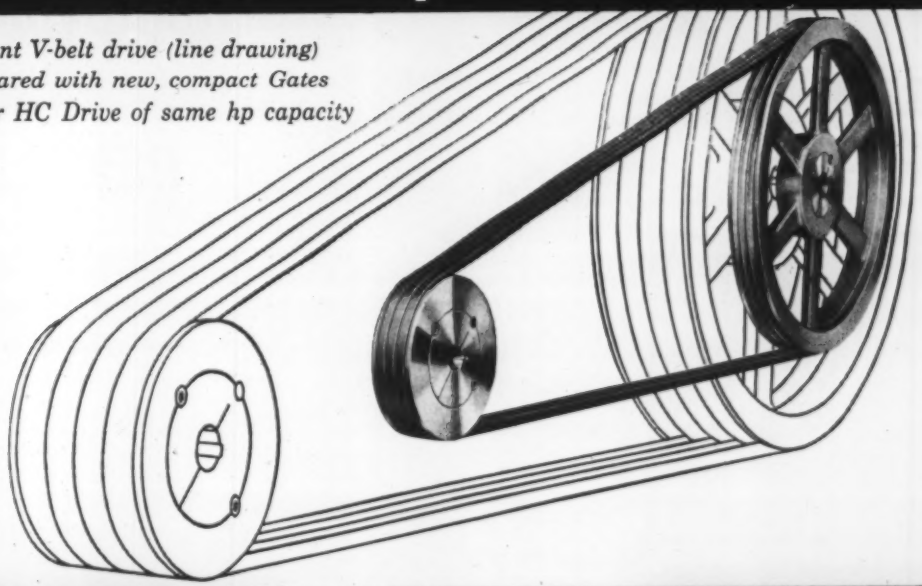
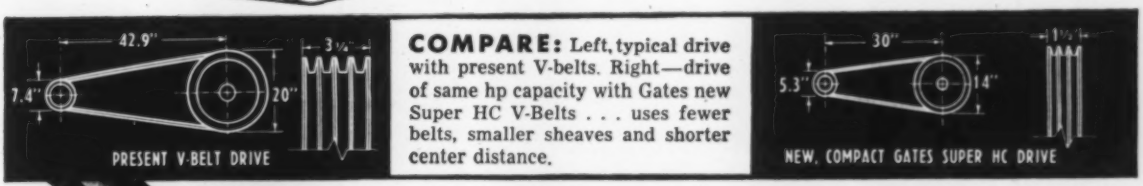
MILFORD 42, NEW HAMPSHIRE
Representatives in Principal Cities

Circle 586 on Page 19

up to 50% LESS SPACE needed for revolutionary new V-belt drive

Present V-belt drive (line drawing) compared with new, compact Gates Super HC Drive of same hp capacity





COMPARE: Left, typical drive with present V-belts. Right—drive of same hp capacity with Gates new Super HC V-Belts . . . uses fewer belts, smaller sheaves and shorter center distance.

Exclusive cross-section design: The precisely engineered arched top, concave sidewalls (U. S. Pat. 1813698) and special tensile construction insure full pulling power and longer belt life.

Reduces drive cost as much as 20%

A major advance in the field of power transmission, the fully proved Gates Super HC V-Belt, makes possible the lowest-cost, lightest-weight, most compact multiple V-belt drive that can be put on any machine!

The cost of a new Gates Super HC V-Belt Drive is as much as 20% less than present V-belt drives of the same hp capacity.

For detailed information on the Super HC Drive, contact your nearby Gates distributor or Gates Office for new booklet, "*The Modern Way to Design Multiple V-Belt Drives.*"

TPA 389

The Gates Rubber Company, Denver, Colorado

Gates Rubber of Canada Ltd., Brantford, Ontario

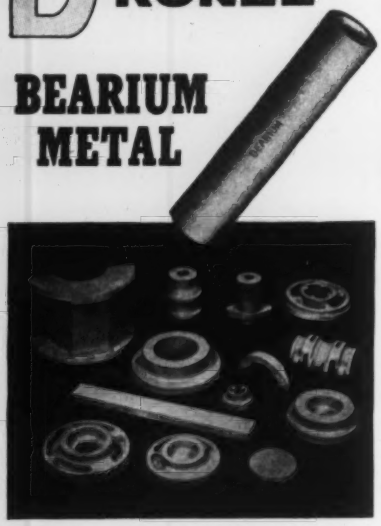
World's Largest Maker of V-Belts

Gates Super HC V-Belt Drives

Circle 587 on Page 19

Your BEST BUY in BEARING BRONZE

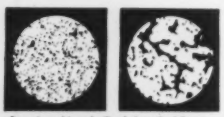
BEARIUM METAL



Words cannot describe the advantages and the superiority which BEARIUM METAL offers over all other types of bearing materials. Only when you use it under the most difficult operating conditions can you appreciate its amazing superiority.

So, if you have a bearing application which involves high speeds, poor lubrication, excessive loads, elevated temperatures, dusty and gritty surroundings—or where a liquid other than oil must be used as a lubricant . . . BEARIUM METAL will prove to be your best investment.

THE SECRET OF BEARIUM METAL'S superiority is due to the uniform distribution of microscopic lead particles within the copper-tin grains rather than between the grain boundaries—as illustrated by these two photomicrographs.



Bearium Metal Ord. Leaded Bronze

FEATURES: Non-Seizing and Non-Scoring • Long-Wearing • Self-Lubricating • Low Coefficient of Friction • High Compressive Strength • Resistant to Shock Loads • Sound, uniform structure • Free Cutting.

AVAILABLE IN: cored and solid bars • centerless-ground rods • machined parts • pattern castings.

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West Coast Affiliate:

NEVIN ENGINEERING ASSOCIATES

208 Toyopa Drive, Pacific Palisades, Calif.

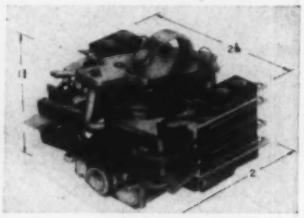
In Canada:

BEARIUM METALS OF CANADA, LTD.

225 CENTRE ST., E., RICHMOND HILL, ONT., CANADA

Circle 588 on Page 19

duction runs. New one-piece frame permits mounting with a single bolt in tapped No. 8-32 core. Length is 2 in., height, 1¾ in., and weight, 3½ oz. Relay transfers contacts when pulsed for approximately 30 millisec, and contacts are returned



by next pulse. No power is required once contacts transfer. Contacts are rated at 7.5 amp, 115 v, 60 cycles, for resistive loads. Unit can be furnished to operate on up to 230 v ac or to 110 v dc. **Potter & Brumfield Inc.**, Princeton, Ind. J

Circle 784 on Page 19

Magnetic Amplifiers

provide power gain greater than 50 db

Preac 60-cps high-sensitivity amplifiers can be used alone or as preamplifiers for data-sensing devices such as thermocouples, strain gages, and bolometers, as well as for high-impedance dc sources. Each unit provides power gain greater than 50 db and full linear output of 2 v into a 5000-ohm load with null

drifts as low as 0.03 ma referred to input. Amplifiers are rated for operation from 60-cps power lines at 115 v. Power drawn is less than 1.5 w. **Seminole Div., Airpax Products Co.**, Ft. Lauderdale, Fla. O

Circle 785 on Page 19

Silicon Rectifier

for high-temperature service

Type 4A heavy-duty, 35-amp power rectifier is available with peak re-

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FOR EVERY APPLICATION ...PRODUCT...PURPOSE

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Interlocked, corrugated . . . braided, plain or rubber covered . . . copper, steel, brass or stainless steel . . . from ⅛" to 24" I.D. Penflex makes all types and sizes for all applications and operating conditions.

Penflex Flexible Metallic Tubing is made for rugged, long lasting service. It defies heat, abrasion, crushing . . . will convey everything from semi-solids to the lightest volatile. Get full information. Write . . . Pennsylvania Flexible Metallic Tubing Co., Inc., 7239 Powers Lane, Philadelphia 42, Pa.

NEW DATA BOOK

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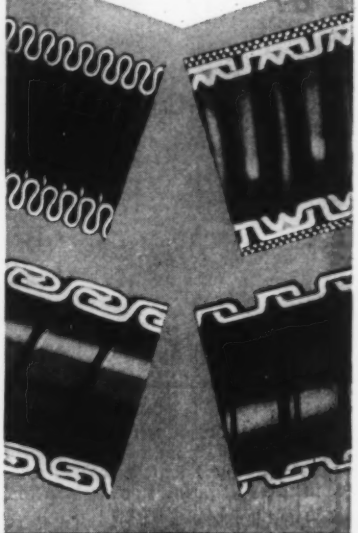

PENFLEX

TIGHT AS A PIPE BUT... FLEXIBLE

Circle 589 on Page 19

Third Conference on Manufacturing Automation

March 23, 24, and 25, 1959

Purdue University, Lafayette, Ind.

For production executives, manufacturing engineers, and administrative managers who plan, design, and install automated systems for industry.

Topics: Organization and Costs, The Process, Handling in Process, and Control of Operations.

Cosponsored by
School of Mechanical Engineering
Dept. of Industrial Engineering
and
AUTOMATION
Cleveland, Ohio

MONDAY . . . . . SESSION I & II . . . . . MARCH 23, 1959

Developing Automation for Flexibility of Output

A PANEL—Manufacturing Engineering—IBM, Endicott, N. Y.

1. ORGANIZATION—**KEITH BENNETT**, Project Engr., Test Equipment Engineering
2. STUDY OF OPERATIONS—**GEORGE PHILLIP**, Project Engr., Mfg. Research
3. DEVELOPING THE HARDWARE—**ALFRED JOHNSON**, Project Engr., Mfg. Research
4. DATA PROCESSING—**WILLIAM ANDRUS**, Manager of Applied Computation
5. ECONOMICS—**RICHARD SEILER**, Technical Ass't to Ass't Mfg. Engr.

Buffet Lunch — **Pioneering in Automation**

WILLIAM ALDEN, President, Automation Management Inc.

Industrial Engineering's Role in Automation of Operations

H. H. YOUNG, Assoc. Prof., Dept of Industrial Engineering, Purdue University

Cost Analysis and Machine Replacement

ROBERT A. LOWE, Managing Partner, R. A. Lowe & Co.

TUESDAY . . . . . SESSION III & IV . . . . . MARCH 24, 1959

Manufacturing Engineering and Machine Procurement

ARMIN FRANK, Manager-Manufacturing, Vacuum Cleaner Dept., General Electric Co.

Assembling Complex Devices

GEORGE WEISER, Chief Process Engineer, Delco-Remy Div., General Motors Corp.

Buffet Lunch — **Automation on the Farm**

E. W. LEHMANN, Prof. Emeritus, Agricultural Engineering, University of Illinois

Handling as the Key to Automation for the Small Company

JAMES R. SEBASTIAN, President, The Rapids-Standard Co. Inc.

Handling Products for Distribution

ALLAN HARVEY, President, Dasol Corp.

Banquet — **Guaranteed Annual Automation**

LEON GREENBERG, Chief, Div. of Productivity, U. S. Dept. of Labor

WEDNESDAY . . . . SESSION V & VI . . . . MARCH 25, 1959

Modern Developments in Control

DR. JOSEPH F. MANILDI, General Manager, Thompson-Ramo-Wooldridge Products Co.

Numerical Control of Production Machines

W. E. BRAINARD, Chief Engineer, Servo Machine Tool Div., Kearney & Trecker Corp.

Buffet Lunch — **Automating the Horses**

O. C. LEVY, Vice President, American Totalisator Co., Div. of Universal Control Inc.

An Institute for Manufacturing Engineers?

Chairman: **R. W. BOLZ**, Editor

• • •

● **FEE**

Fee for the Third Conference on Manufacturing Automation is $75 which will include the Banquet, the Buffet Luncheons, and a copy of the Transactions.

● **LODGING**

Rooms are available at the Union Club on the campus at $4 and $6 single, $6 double, and $7 to $9 twin. Room reservations may be made with the Union Club by the form supplied. Accomodations are also available at the Fowler Hotel in Lafayette (city bus to campus) from $3.50. Write direct. For those driving, reservations may be made at the Morris-Bryant Motel, Cedar Crest Motel, or Green Acres Motor Court (2-4 miles north on U. S. 52). For additional information, write K. E. Glancy, Div. of Adult Education, Purdue University, Lafayette, Ind.

Mail to: AUTOMATION CONFERENCE, Comptroller's Office (Conferences), Purdue University.

ROOM RESERVATION

Please reserve in the Union Club the accommodations checked:

Nights: Mar. 22 ☐ Mar. 23 ☐ Mar. 24 ☐

Single Bed—Bath ☐ Twin Beds—Bath ☐

If necessary, will share twin-bed room with another member ☐

Room will be shared by _____

Please send confirmation:

Name _____

Company _____

Address _____

CONFERENCE REGISTRATION

The following persons plan to attend the AUTOMATION CONFERENCE, March 23, 24, and 25, 1959 (name and title, please):

Name _____

Title _____

Name _____

Title _____

$_____ is enclosed for the registrations checked at $75 each. (Make checks payable to Purdue University.)

☐ Fees will be paid at registration time.

Name _____

Company _____

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Name your most difficult shaft sealing problem, and you've named the best reason for using a Borg-Warner Mechanical Seal on that shaft.

The real practical value of Borg-Warner Seals is their ability to seal *effectively* under the toughest extremes of temperature and pressure ... for toxic, volatile or corrosive fluids ... and even some abrasive liquids. *Result* – less down time, elimination of leakage and expensive stuffingbox maintenance.

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NOW AVAILABLE – a new file folder of Borg-Warner Mechanical Seal designs shows some of the many types and applications possible for mixers, pumps, compressors, autoclaves and for special rotating shaft problems. Send for your copy today – there's no obligation.

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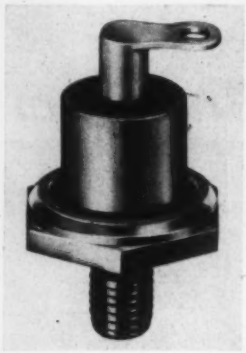
Circle 591 on Page 19

verse ratings from 50 to 400 v in 50-v multiples, and is applicable to all types of power circuits. Rectifier is especially suited to high-temperature operation at ambient temperatures to 165 C. It can be



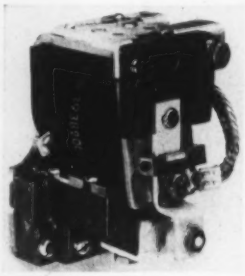
mounted in any position. Entire unit is hermetically sealed and has a standard $\frac{1}{4}$-28 mounting stud. **Fansteel Metallurgical Corp.**, Dept. MDC, North Chicago, Ill. J

Circle 786 on Page 19

DC Contactor

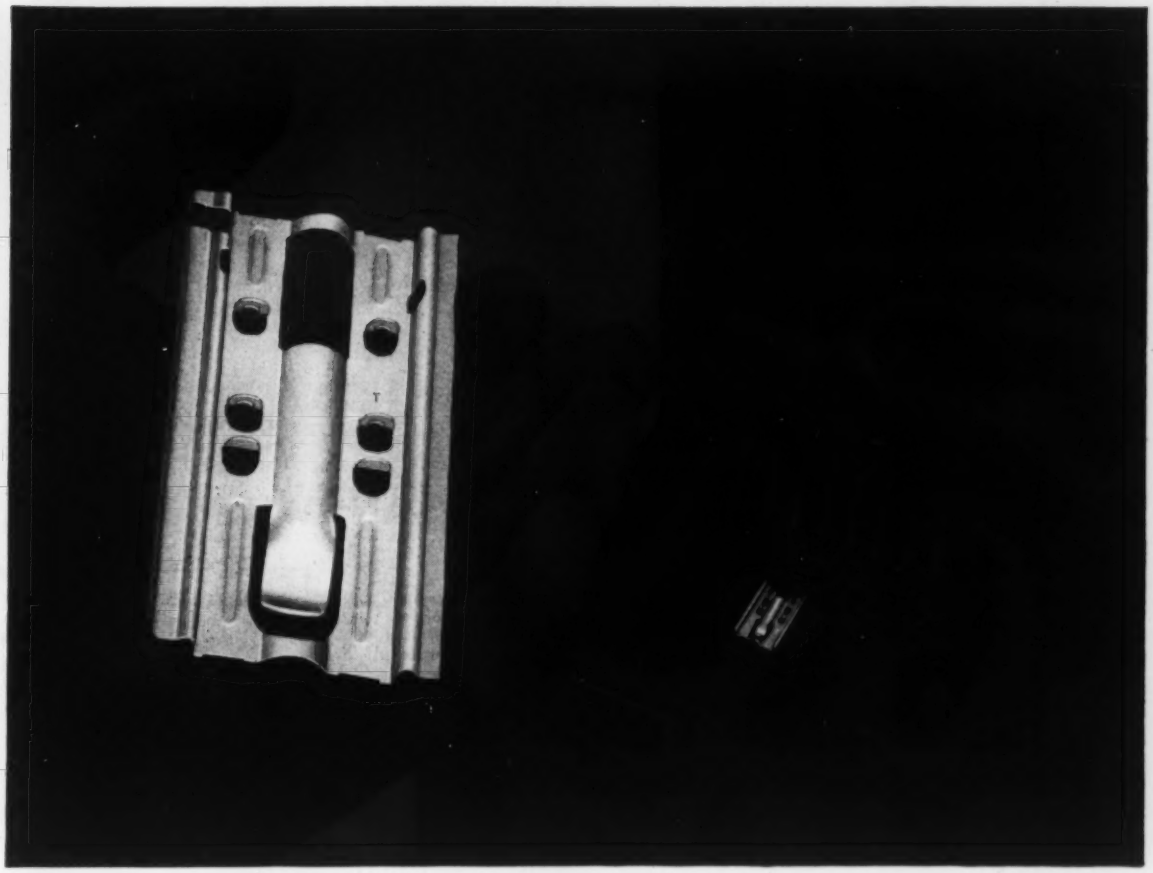
100-amp unit has new coil design

New 100-amp contactor is for application on electric-powered vehicles up to 36 v. Efficient coil design permits manufacture of smaller coils without sacrifice in performance. Contactor is only 4 7/32 in. high, 3 in. wide, and $3\frac{3}{8}$ in. deep. Pneu-



matic timer, adjustable from 0.1 to 3 sec, features exceptionally long life and excellent repetitive accuracy. Unit is available in single-pole normally open, single-pole double-throw models. Contactors are unit mounted, front connected, and house coils equipped with lug terminals. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 787 on Page 19



Engineered by Tinnerman...

Easier to assemble...easier to operate... **SPEED CLIP**® costs 50% less, too!

Assembly of the SUPER-FILER® *Divide-a-File* mechanism was considerably simplified when the General Fireproofing Company switched to a special SPEED CLIP design. Sightless people do the assembling without former difficulties of fitting spring wires into non-uniform stampings.

With this SPEED CLIP, the "self-adjusting" *Divide-a-File* slides more smoothly back and forth in the channel. Locking in the desired position is more positive, too.

This is another example of how Tinnerman Engineering goes far beyond the original fastening idea—how we work with customer engineering departments to produce better working units. And in the above case, a per-part cost reduction of 50% was achieved. In only 4 months, General Fireproofing had saved enough through lower assembly and parts costs to write-off new tooling needed to produce the SPEED CLIP.

You, too, can achieve savings and improvements like these on your assemblies. Invite your local Tinnerman sales representative in for a discussion of the SPEED NUT methods of better fastening at lower cost. He's listed in most Yellow Pages, under "Fasteners". Or write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

Since World War II designers of air and space craft have made ever-increasing use of honeycomb in a great variety of structural and non-structural applications. Honeycomb can be made from almost any material available in continuous web or roll form, e.g., aluminum, glass fabric, cotton, stainless steel, paper, asbestos, titanium. In its cellular configuration, honeycomb is 97% air, 3% material.

Honeycomb has intrinsic qualities of high strength, light weight, high ratio of surface area to volume and other specific properties which depend upon the type of material used. These combinations of properties, which have given honeycomb wide application in air and space craft, offer to designers in industry generally unique opportunities in product design.

In the interest of advancing this knowledge of honeycomb, Hexcel, through its research and development staff (the industry's largest), has prepared this informational series. Should you desire additional technical information, please complete the information request form on this page. Your request will receive immediate attention.

INFORMATION REQUEST

Send to Hexcel Products Inc. Dept. "D"
2332 Fourth Street, Berkeley 10, California

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HEXCEL PRODUCTS INC.
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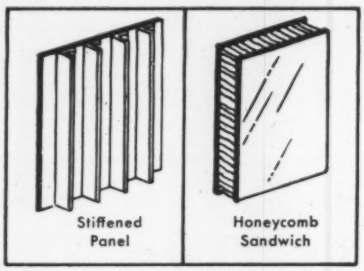
Executive offices: 2332 Fourth St., Berkeley, California. Plants: Oakland and Berkeley, California; Havre de Grace, Maryland. Sales Offices: Inglewood, California; Fort Worth, Texas; Long Island City, New York.

HONEYCOMB SANDWICH PANELS

Strength/Weight Ratio

Traditional design of flat panel structures to resist bending or column loading has been to use either thick plates or thin sheets stiffened with angle extrusions to form a more or less rigid panel. Where end use of panel requires a high stiffness-to-weight ratio or a superior strength-to-weight ratio, many designers have turned to the use of sandwich structure.



Sketch #1

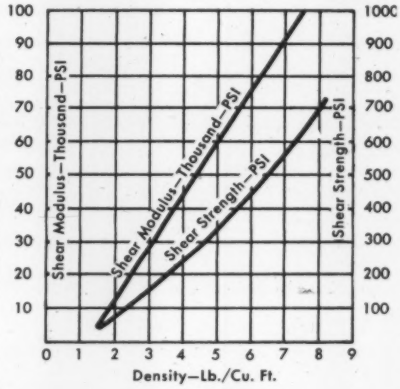
In a sandwich structure, the panel is made up of two faces with a light weight core material between them. In order to qualify as a structural sandwich, the core must be rigidly attached to the two faces. When these requirements are met, the resulting structure is capable of the highest strength-to-weight and rigidity-to-weight ratios presently obtainable by ordinary design methods.

Sandwich Structures:

A Design Approach

Sandwich structures are really a method of design approach rather than a single material. It is possible to design structures precisely tailored to fit the requirements at hand. Not only can the thickness and type of facing material be varied, but the thickness and density of the core material is subject to the designer's choice.

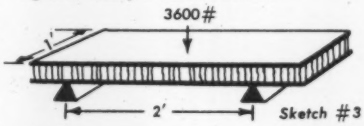
In the two curves shown, shear strength and shear modulus are given for Hexcel aluminum honeycomb in densities ranging from two to eight pounds per cubic foot. The strengths these core materials develop compare favorably with the strength of much heavier cores of plastic foam, wood fibers or other less efficient materials.



Sketch #2

Bending Loads

Bending strength and the bending rigidity of sandwich panels are two primary reasons for their broad acceptance in the area of light weight structures. In comparing panels loaded as shown in the sketch below, it can be shown that honeycomb sandwich is by far the lightest of any usable structure.



Sketch #3

3600 LB. WEIGHT - - - - - 24" SPAN

Material	Deflection (in inches)	Weight (in pounds)
Honeycomb Sandwich	.058	7.79
Nested "I" Beams	.058	10.86
Steel Angles	.058	25.9
Aluminum Plate	.058	34.2
Magnesium Plate	.058	55.0
Steel Plate	.058	68.6
Glass Reinforced Plastic Laminate	.058	83.4

The list of weights and deflections in the above table gives a clear indication that honeycomb sandwich panels have broad areas of application.

Circle 593 on Page 19

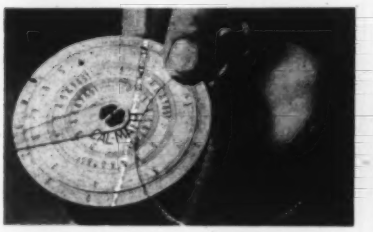
ENGINEERING DEPARTMENT

EQUIPMENT

Pocket Calculator

circular unit has 3½-in. diam

Cal-Math circular slide rule consists of two flat metal discs, plus sliding indicator. Discs are anodized green and gold to eliminate error in use. Easy, permanent reading is assured through a new metal imprinting process, extra large graduations, and



increased spacing between scales. Only 3½ in. in diam, unit is made for accuracy to thousandths. It multiplies, divides, calculates discounts and percentages, solves problems in square and square roots, cube and cube roots, fractions, decimals, proportions, successive multiplication and division, and problems using π. Rule is unaffected by atmospheric corrosion, perspiration, and fingering, and is abrasion resistant under normal use. It is furnished with plastic case. **Cal-Math Co.**, P. O. Box 5536, Philadelphia 43, Pa. E

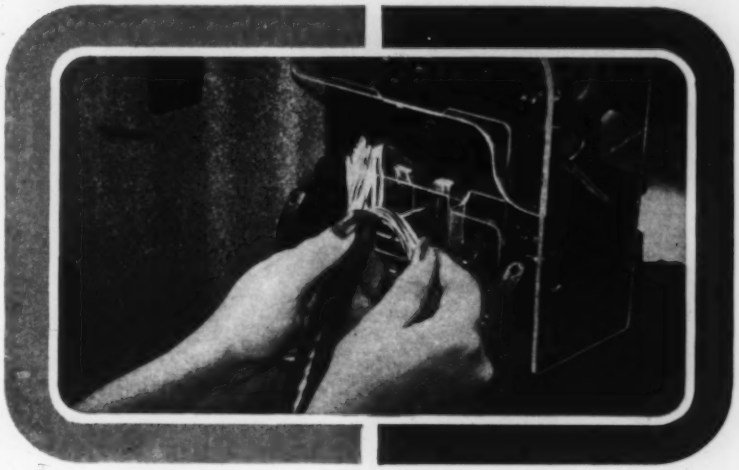
Circle 788 on Page 19

Analog Computer

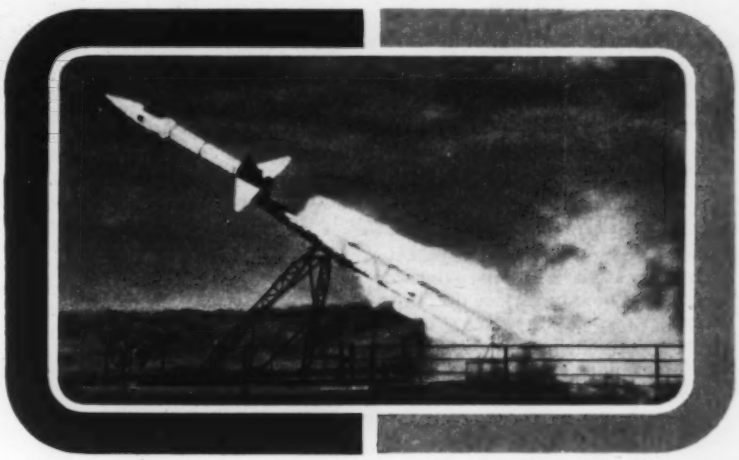
is available in kit form

Heathkit EC-1 computer is completely self-contained, including nine dc operational amplifiers, three initial condition power supplies, five coefficient potentiometers, four sets of relay contacts, electronically regulated power supply, and repetitive oscillator for automatic operation. Included with kit is an assorment of precision resistors, Mylar capacitors,

Circuit Terminations Made Here



Do Not Fail Here



Each click of the dies in this A-MP Automachine indicates the completion of another top quality termination. This completely mechanical "crimp" means that there will be no variations in quality, no failures in service. The A-MP terminal actually becomes a homogeneous part of the wire end, supporting it against vibration, resisting corrosion, and affording the soundest electrical performance.

The A-MP Automachine literally "mints" these attachments at the rate of thousands per hour . . . and at a minimum cost to you. Time and time again, AMP has proven that its method costs less and assures higher reliability than any other termination method.

Whether your problem is reliability, production volume or installated cost, AMP can help you. Why not send for descriptive literature today?

AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

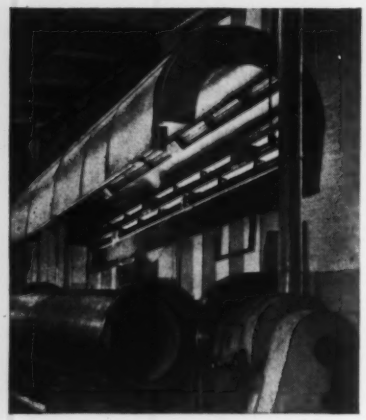
A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

Circle 594 on Page 19

...the U.S. Navy's new Mark 32 fibre-glass torpedo launcher

From its unlikely beginning as a fibre-glass mat . . . to its successful operation in sub-freezing sea spray . . . the Mark 32 torpedo launcher testifies to the versatility and dependability of Chromalox electric heat. Designed and built by Apex Reinforced Plastics, division of White Sewing Machine Corp., this lightweight, corrosion-resistant launcher is now in service on Navy destroyer escorts.

Early in production, a Chromalox-heated hood is used in centrifugal molding of the launcher tubes.



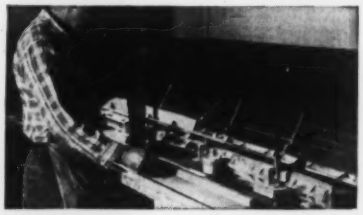
First, a rolled fibre-glass mat is placed inside the mandrel, which is then engaged in spinning motion at 800 rpm. After thermosetting resin has been sprayed into the mandrel, the hood is lowered into position for heat curing. The Chromalox type RAD Far-Infrared Heaters have a total capacity of 36,600 watts, and reach approximately 200°F. in about 45 minutes. The hood remains on a total of about 3½ hours, throughout the spinning operation.

Before final assembly, each tube must have steel "nut bars" and "guide bars" cemented to its interior. (Nut bars connect the three tubes into one assembly; guide bars guide torpedoes into the launcher tube.) After these parts are cemented in place, two Chromalox Tubular Heaters wired in series set the cement.

Mounted in a frame which holds them in the center of the tube for its entire length, the 240-volt, 2750-watt heaters are controlled by a Chromalox type AR Thermostat. A small fan attached to the end cap circulates heat within the tube and eliminates condensation.

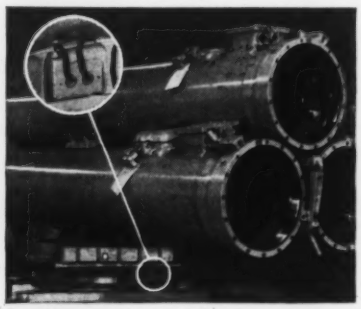
Next, four plastic quadrants are bolted to the tube interior, forming a liner to accommodate 12¾-inch torpedoes. To each quadrant are affixed two 101-inch Chromalox Flexible Woven Heaters.

After resin has been applied to the two channels in each quadrant, heaters are laid in place as shown below. The leads are then connected



to a power outlet and the heaters set the cement which bonds them in place. In action, these heaters maintain a protective 50°F. minimum temperature for the torpedo.

The closeup below shows two leads of a circular Chromalox Tubular Heater clamped in a groove around the launcher's swivel base. To prevent formation of ice in the joint between fixed and rotating parts of the base, this heater comes on automatically when the temperature drops below 50°F.



Plastic bottles, containing air at 2000 psi, provide pneumatic force to launch the torpedoes. Fabrication of these bottles, by the unique Apex filament winding process, involves still another Chromalox Heat application. After the plastic bottle has been formed around a Cerro-alloy ball mold, the alloy must be melted from the bottle's interior. Four sets of Chromalox Strip Heater Bands and a Chromalox Ring Heater provide booster heat on the steam-heated vat used for this purpose.

Perhaps one of these heaters, or one of the 15,000 other types, sizes and ratings of Chromalox Heaters can answer your need for heat. For personal assistance and specific recommendations, *Call your Chromalox Man for the Answers.* He's listed at the right. 7787

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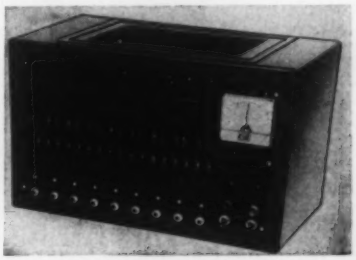

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Drafting Table

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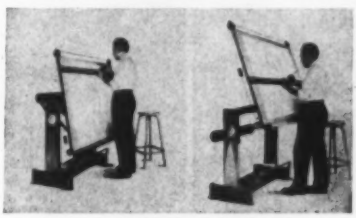

sizes are available: 40 x 60; 34 x 47; 26 x 36; 27½ x 40 in. **Stacor Equipment Co.**, 285 Emmet St., Newark 5, N. J. D

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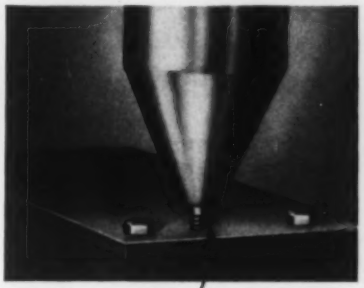

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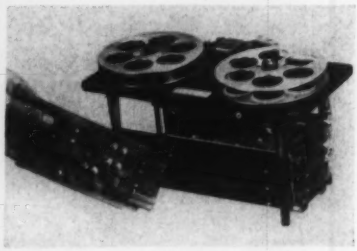


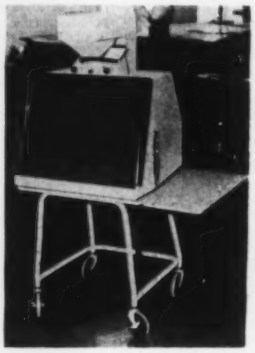
torized record-reproduce electronics. Tape speed ranges from 0.05 to 17/8 ips, accurate to 0.1 per cent. Unit provides up to 60 hr of recording. It withstands 10 g vibration and 30 g shock along each axis. **Precision Instrument Co.**, 1011 Commercial St., San Carlos, Calif. M

Circle 791 on Page 19

Microfilm Reader

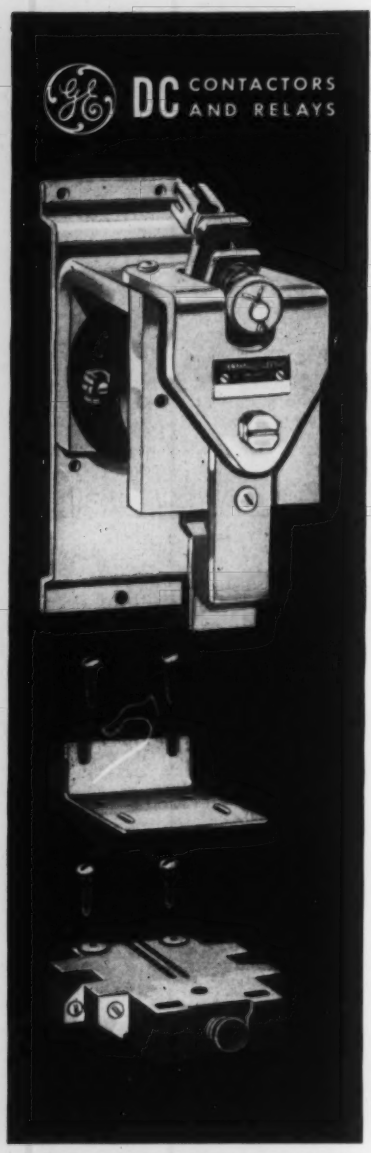
has nominal magnification of 15 times

Designer 184 has a screen size slightly larger than 18 x 24 in. with optical system that covers entire microfilm frame within Military D aperture. With nominal magnification or 15 times, unit enlarges A, B, and C drawing sizes filmed at 16X reduction to almost full size. Larger drawings, filmed at 30X reduction, are enlarged to half size. Card and film are held in plane by a plastic holder designed specifically for punch cards and 3 x 5 cards. Holder can be rotated 90 to 180 deg and has card stop for Military D location. Lens is 65-mm f/4, which distributes 20 to 25 ft-c light



throughout screen **Filmsort Co., Div., Miehle-Goss-Dexter Inc.**, Pearl River, N. Y. D

Circle 792 on Page 19



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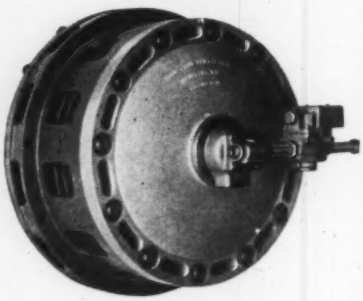

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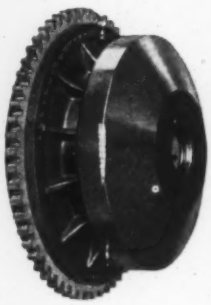

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Recent Books

Electronic Engineer's Reference Book. *Edited by L. E. C. Hughes; 1311 pages, 4¾ by 7¼ in., clothbound; printed in Great Britain; distributed by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$18.00 per copy postpaid.*

Over 50 experts present the latest information and techniques in electronics application. Suggestions and possibilities are provided for problems considered from any viewpoint—physical, chemical, production, safety, reliability, or maintenance.

Covered under "radiations" are infrared and ultraviolet sources and industrial applications, lighting, photoelectrics, and radio-frequency heating. Conduction and transmission, electrolytic corrosion, and high-voltage machines and transformers are discussed.

Various types of radio tubes and transistors, their use, and tables and diagrams describing them make up the largest section. Other chapters on fundamentals, materials, vibrations, computers, and applications of electronics in automation provide additional reference information.

Proceedings for a Short Course - - - - *The following two books are 8½ by 11 in., paperbound; available from J. Marin, Dept. of Engineering Mechanics, The Pennsylvania State University, University Park, Pa.*

Mechanical Properties of Metals. *Edited by L. W. Hu, associate professor of engineering mechanics, and Joseph Marin, professor and head, Dept. of Engineering Mechanics, both of The Pennsylvania State University; 296 pages; $8.50 per copy.*

To disseminate information on recent developments, the 12 lectures contained in this book comprised a short course on the determination, interpretation, and significance of mechanical properties of metals. Topics include elastic and plastic behavior, creep resistance, fatigue

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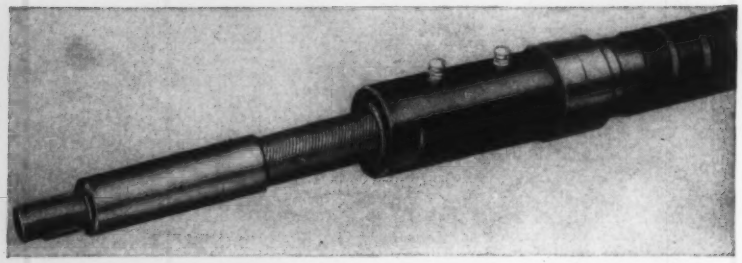
HOW TO SELECT FLEXIBLE SHAFTING FOR POWER DRIVE APPLICATIONS



1¼-inch STOW Power Drive flexible shaft with core assembly pulled out of casing.

For Power Drive applications, the following factors must be considered:

1. Torque (Lb. In.) to be transmitted. (The starting torque should be used in making selections.)

2. Operating Speeds (RPM) — If the maximum speed is higher than the rated speed, torque ratings in the table below do not apply. To find the torque capacity for flexible shafts operating at speeds higher than the rated speeds, multiply the maximum dynamic torque capacity by the rated speed, and then divide by the operating speed. (See example).

3. Operating Radius—In making the selection from the table below, the radius of the smallest bend in the flexible shaft should be used.

Ratings — The ratings for flexible shafts shown in the table below apply under the following conditions:

1. When the flexible shaft is adequately supported by clamps along its length. (For unsupported shafts, multiply the calculated torque by a safety factor of 1.6—see example below.)

2. When the flexible shaft is operated in the wind-up direction, which tends to tighten the outer layer of wires. (Flexible shafts operated in the unwind direction will transmit only about 60% of the rated torque.)

3. When the flexible shaft is in continuous operation. Note: **the ratings are based on temperature rise. When the operation is intermittent, the ratings in the table may be exceeded. Consult Stow engineers for specific recommendations.**

RATED SPEED R.P.M.	MAXIMUM DYNAMIC TORQUE CAPACITY (LB. IN.) STRAIGHT AND CURVED SHAFTS RADIUS OF CURVATURE IN INCHES									Wgt./ C. Ft.	Core Dia.	Core No. and Type	Shaft Size
	50 to Strgt.	25	20	15	12	10	8	6	5				
4,500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	3.0	.124/.128	2049 MH	13
3,800	7.0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	4.5	.148/.152	2081 MH	15
2,900	9.4	8.6	8.0	7.6	7.0	6.6	6.0	4.8	3.4	7.0	.185/.189	5108 MH	19
2,500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0	12.5	.247/.252	8924 MH	25
1,800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0		20.0	.308/.313	8925 MH	31
1,800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8		20.0	.308/.313	8969 T	31
1,800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0	21.0	.324/.329	2034 A	31
1,500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0		28.5	.368/.374	2035 A	38
1,500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0		29.0	.387/.393	8970 MH	40
1,500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0		29.0	.387/.393	8971 T	40
1,150	136.0	110.0	104.0	94.0	80.0	72.0	56.0			50.5	.497/.503	8999 A	50
1,150	148	124	110	92	72	56				53.5	.505/.511	6940 T	50
900	248	200	176	124	84					78.5	.610/.618	6997 T	63
900	220	204	192	180	152	130				80.5	.630/.638	7731 A	63
750	340	224	156	76						117	.747/.753	2056 T	75
600	760	520	420							205	.998/1.004	2057 T	100
440	1,500	720								343	1.298/1.304	2058 T	125

EXAMPLE — How to use the table:

The problem is to transmit ½ H P at 1700 RPM through an unsupported flexible shaft in a 25" radius, estimated starting torque 150% of normal operating torque.

1. Calc. Torque (lb. in.)—
$$\frac{HP \times 63000}{RPM} = \frac{.5 \times 63000}{1700} = 18.5$$
2. Correction factor for starting torque 1.5 x 18.5 = 27.75
3. Correction factor for unsupported shaft 27.75 x 1.6 = 44.4 lb. in.
4. Refer to Table above. Read downward in column under 25" radius until you find a core having a rating of at least 44.4 lb. in. In this case we find that core no. 8970 is rated 54 lb. in. at 1500 RPM. Since the given speed is 1700 RPM, multiply 54 by 1500 and divide by 1700. 54 × 1500 ÷ 1700 = 47.6 lb. in. (rated torque at 1700 RPM). Therefore, Core No. 8970 is correct.

STOW

For Engineering Bulletin No. 570 and a free torque calculator, write

STOW MANUFACTURING COMPANY

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Circle 601 on Page 19

strength, temperature effects, impulsive loading, radiation, and testing.

Materials Engineering Design for High Temperatures. *Edited by Joseph Marin, professor and head, Dept. of Engineering Mechanics, The Pennsylvania State University; 418 pages; $9.50 per copy.*

In this short course are nine lectures on material behavior at elevated temperatures. Discussions of creep and deformation, brittle-fracture, thermal stress, and fatigue are related to steam-turbine, nuclear-reactor, aircraft-structure, and gas-turbine applications.

Handbook of Physics. *Edited by E. U. Condon and Hugh Odishaw; 1459 pages, 7⅛ by 9¾ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN; *$25.00 per copy postpaid.*

Similar to handbooks serving other professions, this first edition contains the latest concepts and methods available. Principles of physical science and mathematical techniques for expressing them are emphasized.

Sections on mechanics cover vibration theory, orbital motions, control mechanisms, wave propagation in fluids, statics of elastic bodies, and stress analysis. Electrical coverage includes electronic circuits, measurements, dielectrics, and conduction in gases.

Kinetic theory of gases, heat transfer, chemical thermodynamics and kinetics, and thermodynamic properties of solids are discussed in another section. Other main areas are mathematics, solid-state physics, optics, and atomic and nuclear physics.

What Every Supervisor Should Know. *By Lester R. Bittel; 451 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.95 per copy postpaid.*

To guide the plant or office supervisor, this book stresses the relation of practice to principle; integration of changes in methods, goals, external factors, and in himself; practicality based upon experiences; maintenance of good-humored per-

spective; and information needed for dealing with men, money, machines, and materials. Question-answer type text, case studies, and charts are used to define and resolve supervisory responsibilities and problems.

Machine Tools for Engineers. *By Charles R. Hine; 445 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.75 per copy postpaid.*

Block diagrams, new sketches, rearranging, and rewriting in this second edition better explain the uses and mechanisms of machine tools. Only the latest models are pictured.

New machine tools and manufacturing processes included are chemical milling, electrical-discharge machining, ceramic tools, the Floturn lathe, electric broaching, and skin milling. Automatic machine tools are discussed in a new chapter.

Advanced Mechanics of Fluids. *Edited by Hunter Rouse, professor of fluid mechanics, State University of Iowa; 444 pages, 5¾ by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN; *$9.75 per copy postpaid.*

This textbook, by members of the Iowa Institute of Hydraulic Research, is directed toward teaching modern techniques of analytical research in fluid motion. To deal with the combination of mathematical and experimental analysis, various aspects of dimensional characteristics needed for correct physical relationships are initially outlined. Then follows the approach to new problems through flow representation, classical hydrodynamics, viscous flow, and fluid turbulence.

New Standards

NEMA Standards Publication, Motors and Generators, MG1-1959. *273 pages, 8½ by 11 in., paper covered, ringbound; available from National Electrical Manufacturers Association, 155 East 44th St., New York 17, N. Y.; $10.00 per copy.*

This standard provides practical information concerning construction, test, performance, and manu-

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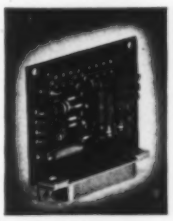

Conventional circuitry is a maze of wire and spaghetti. It is costly to assemble and unpredictable in performance. A printed circuit on TAYLOR rolled copper-clad laminate is a strong prefabricated part of known reliability. This quality is largely due to the new finish on the copper. Both solder and ink go on uniformly. The handling of one part alone can cut assembly costs as much as 65%. And there is an important passalong benefit: field repairs, when necessary, can be made easier and more economically. Write TAYLOR FIBRE CO., Norristown 47, Pa., for complete details.

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Circle 602 on Page 19

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facture of ac and dc motors and generators. It supersedes Publication No. MG1-1955.

General sections include definitions, standard ratings and dimensions, frame assignments, and application data. Specific sections deal with synchronous motors and generators, dc generators, dc and induction motors rated over 200 hp, and motor-generator sets. Definite-purpose motors cover universal, fractional, and integral-horsepower parts, features, and special applications.

American Standard B27.1-1958, Lock Washers. *21 pages, 8½ by 11 in., paperbound, stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $2.00 per copy.*

Covered in this standard are dimensions, physical properties, and methods of testing for: 1. Spring lock washers of carbon steel, stainless steel, aluminum-zinc alloy, phosphor bronze, silicon bronze, and K-Monel. 2. Carbon steel tooth lock washers. 3. Lock-washer machine-screw assemblies.

Main revisions are inclusion of sizes 1⅝ through 3 in. in the light and heavy spring washer series, decision to show tolerance on nominal thickness of spring washers, and inclusion of specifications for the hardened screw and lock washer assemblies.

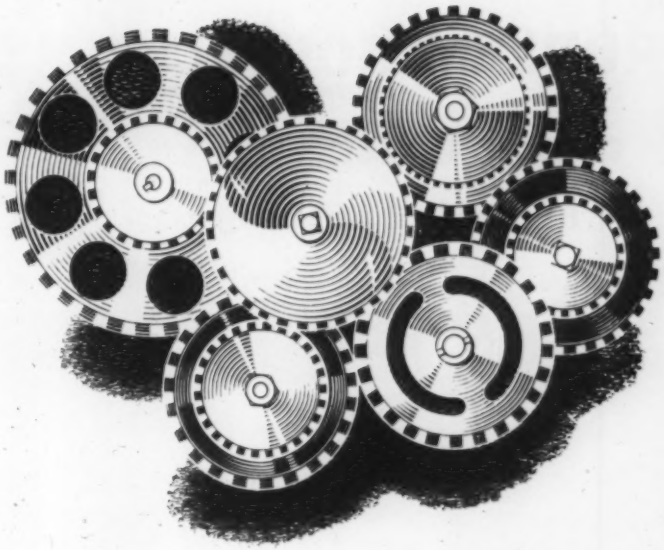
Government Publications

OTS Technical Reports. *Copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following reports are available:

PB 131791. Selected Bibliography on Precision Instrument and Fluid Bearings with Annotations. By Joel G. Weir, U. S. Naval Avionics Facility; 103 pages, 8 by 10¼ in., paperbound, stapled; $2.50 per copy.
References groups chronologically under design and selection, failures and causes, fluid bearings, jewel bearings, lubrication and lubricants, maintenance, manufacturing methods materials, packaging and preservatives, testing and inspection.

PB 131983. Preparation of Standards and Test Procedures for Printed Circuits. By Clyde A. Dodge and Samuel E. Graf, for WADC; 146 pages, 8 by 10½ in., paperbound, side-stapled; $3.00 per copy.
Describes research and development that led to tentative military specifications for "Printed Circuit Plastic Base Materials, Unclad and Foil-Clad," and "Printed Circuit Boards Composed of a Conductor Pattern on Plastic Sheet Material"; new test methods developed; examines reliability of component lead joints to printed circuit conductors.



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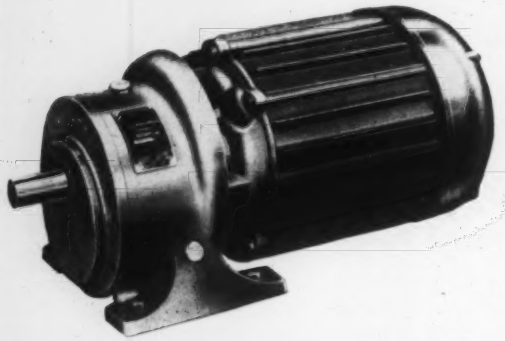

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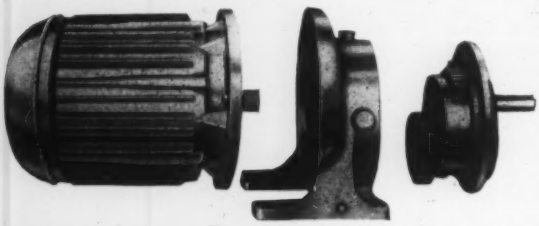

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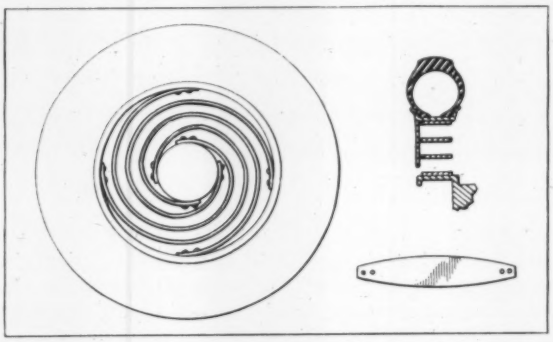
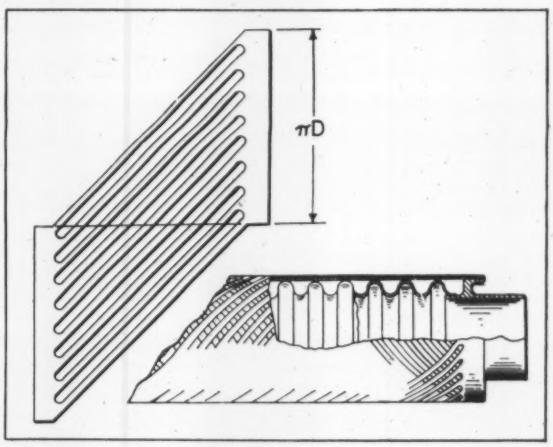
Flexible Wheel Structure

A number of springs, each bent into a flat spiral 360 deg long, comprises a flexible web in a vehicle wheel subject to irregular shock loads. At one end, the



springs are fixed to an axle mounting; at the other, to the inside wheel rim. Due to location, the springs function closer to the source of shocks, thus decrease unsprung weight. The springs carry both tangential and radial loads. Their width, perpendicular to the plane of the wheel, offers maximum resistance to axial deflection. This performance can be supplemented by side plates. *Patent 2,869,608 assigned to Palm-Roy Inc., La Grange, Ill., by John M. Chamberlin and George A. McElroy.*

Thrust-Resistant Flexible Hose



Flexible hose, subject particularly to axial force from high-pressure fluid it carries, is reinforced by multiple wrappings of slotted sleeves. Unwrapped, the sleeves are shaped like parallelograms. Angles between the

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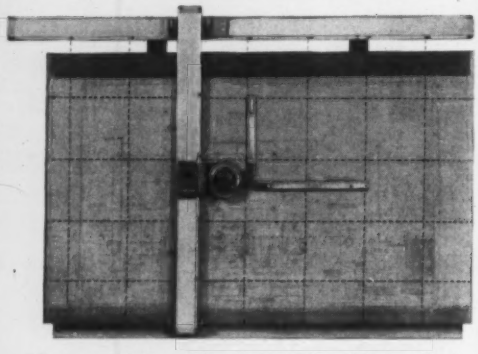

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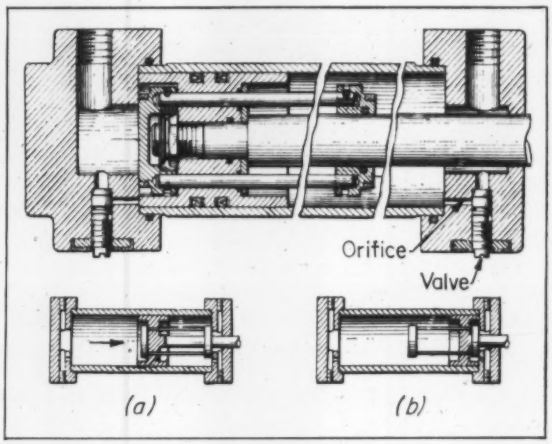
slots and ends of the sleeves are the helix angles in the wrapped state. Widths of sleeve ends equal the circumference of the basic hose. When more than one sleeve is used, the second is wrapped opposite-hand to the first. The result is a conduit having a flexible diamond pattern. Materials for the sleeves may be steel, brass, aluminum, or certain plastics. *Patent 2,867,242 assigned to North American Aviation Inc., by Clare W. Harris and Lawrence M. Nelson.*

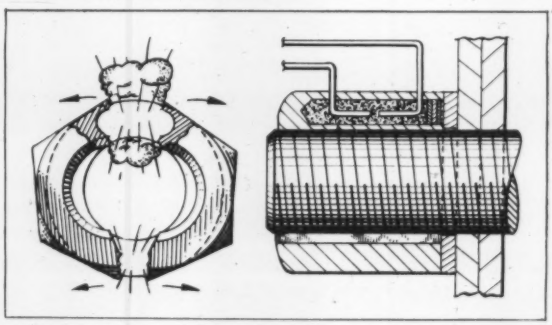
Adjustable Power Piston Damper

Carried by the piston in a fluid power cylinder, an assembly of two valves cushions moving parts at the ends of strokes. The valves are joined and spaced by



rods free to move axially in the piston. In each power stroke, one of the valves reaches and closes the outlet port before the piston, *a*. As the piston travels the remaining distance, *b*, outgoing fluid is forced through an orifice and a metering valve. Cushioning action can be adjusted by changing the length of the plate valve rods or by resetting the metering valves. *Patent 2,870,744 assigned to Hanna Engineering Works, Chicago, by Harold C. Hallerstrom.*

Explosively Released Nut



A bolted connection is released almost instantaneously by ignition of an explosive charge in the nut member. The explosive is carried in a chamber formed in the nut body, parallel to the nut axis. Diametri-

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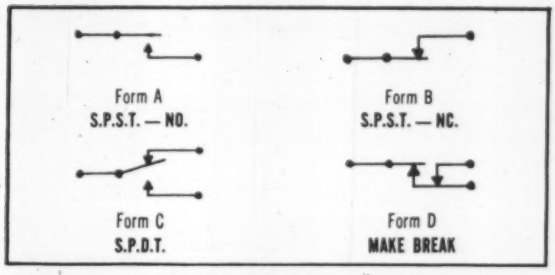
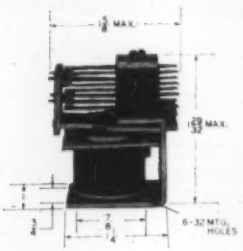
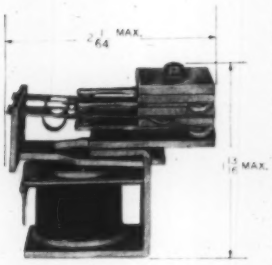


General Purpose Relay Capsule Checklist of Quality Features:



1. Low residual magnetism due to use of silicone steel in magnetic circuit.
2. Coil temperature rise is lower than most other relays.
3. Better coil life than paper tape wrapped coils. (Acro uses Cotton Acetate tape . . . has no electrolytic corrosive effects on the magnet wire.)
4. Single screw stack construction greatly reduces possibility of dielectric failure in the switch stack.
5. Absence of coil type armature return spring eliminates possibility of "snagging" wire and harness when assembling in your unit.
6. Special leaf-type armature return spring allows close control of contact pressure by adjusting specifically for 1, 2, 3, or 4 switches in the "stack".
7. Common terminals on side of switch "stack" eliminate confusion when you're wiring your assembly.
8. Absence of "lances" and "punches" in the frame allow better magnetic circuit and operation further below the saturation point of the material.

Acro Power Relay



You get low residual magnetism because of premium silicone steel in the coil core and relay frame. Coil temperature rise is lower (sometimes as much as 15° F. lower) than competitive relays. Ingenious design eliminates requirement for return spring, gives you choice of bottom or rear mounting, with 6/32 screws. Switch or coil is easily replaced . . . there is a choice of coil voltages. With Acro . . . you get the advantage of a small size with a large inductive load capacity.

. . . and because Acro relays dissipate less power, the coil runs cooler — up to 15° F. in some cases. Silicone steel in the magnetic circuit virtually eliminates sticking due to residual magnetism — assures prompt releasing.

Acro Design Eliminates Coil-Type Return Spring

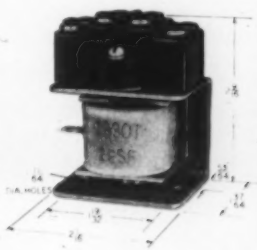
A BIG advantage — because it removes the possibility of "snagging" wires or cables when installed in your unit. And, because there are no cutouts in the frame (necessary when a coil-type armature return spring is used), the magnetic circuit is operated even further below its saturation point. Acro's special leaf-type armature return spring permits close control of contact pressure — and can be adjusted for a stacked relay of 1, 2, 3, or 4 sections.

Mounts In Less Than A 1½" Square!

Acro relays require less than a 1½ inch square area for mounting, but give "Big Switch" performance, with contacts rated up to 10 amps.

When you install Acro relays in your equipment, you virtually eliminate production problems, because the common terminals of an Acro stacked switch assembly are all on the side of the stack.

Heavy Duty Power Relay



Designed to take a heavier load, Acro Heavy Duty Power Relays will work where others fail. The switch is UL approved for 2 H.P. and features a low price tag for its performance. You can easily replace the switch or coil without dismounting the relay.

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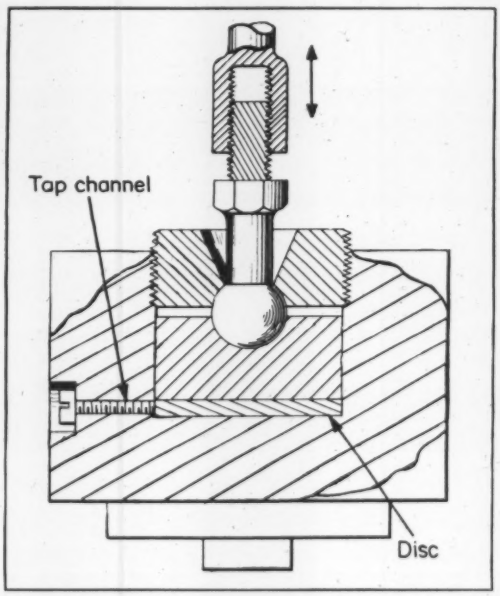
cally opposite the chamber is a V-groove in the nut ID. Any standard nut can be modified this way. Explosion, triggered by electric leads, parts the nut adjacent the chamber. This fracture causes stress concentration at the V-groove, and the nut parts there too. As the nut halves fall away, the bolt is withdrawn by a helical spring carried under the bolt head. *Patent 2,871,750 assigned to Northrop Aircraft, Hawthorne, Calif., by Norman Charles Parrish.*

Emergency Stroke-Adjustment System

Jamming of a reciprocating thrust assembly, such as the ram of a crank press, is relieved by tapping molten metal from a fusible disc located in the line of



action. Usually, jamming occurs just ahead of bottom dead center. In that case, the disc is heated and enough of its material is drawn off so that the crank can pass dead center and free the jam on the upstroke. Consequent changes of disc thickness are accommodated by a threaded coupling, in the connecting rod. *Patent 2,869,453 assigned to Western Electric Co., by James A. Horn.*

Uniform-Torque Ratchet Drive

Regardless of torque fluctuations from a constant-speed power source, a leaf-spring transmission delivers constant torque to a ratchet output at fixed time intervals. From a source, such as a synchronous motor, torque is delivered to a cam continually in contact with a pin in a cradle member. The cradle and the spring it houses oscillate about a single post. The cradle has a slot in which the spring is hooked, and an arc portion which acts as a fulcrum in bending the spring. Lobes on the cam cause spring deflection, hence ratchet indexing. Accuracy and shape of the

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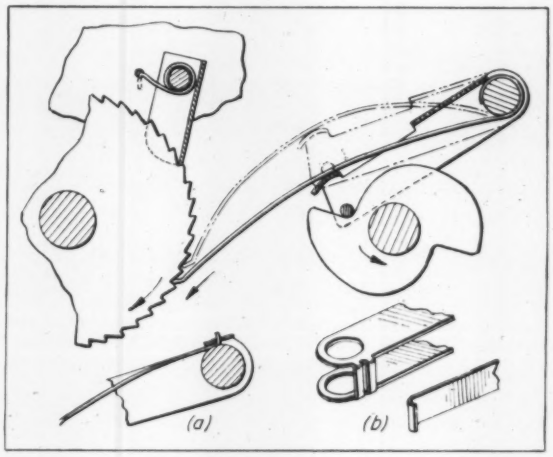
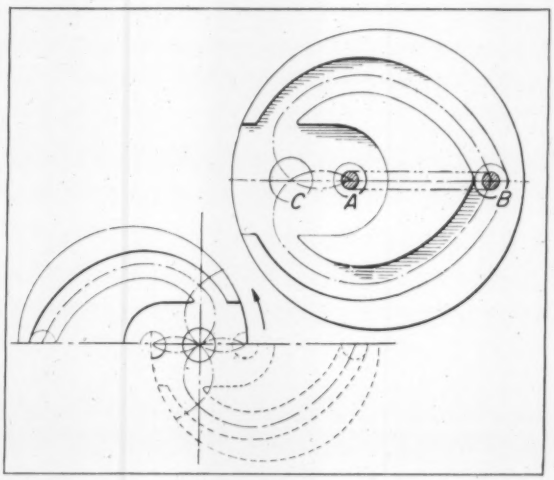


cam contour determine the uniformity and pattern of spring thrust. *Patent* 2,868,026 *assigned to P. R. Mallory & Co., Indianapolis, Ind., by Lyman J. Finehout, Kenneth L. Ebershoff, and James H. Overman.*

Long-Throw Cam-Follower Assembly

More "throw" of a two-pin follower is provided by a face cam than could be obtained by a plate cam of about the same size. Heart-shaped and symmetrical,



the groove opens into a "clearing," of groove depth, around the cam shaft axis *C*. As one follower pin leaves the groove and enters the clearing, the other pin does the opposite. Thus, the groove engages only one pin at all times. Maximum follower throw is the distance *AC* + *BC*. For a plate cam, practical maximum throw is less than *BC*. *Patent* 2,871,723 *assigned to Universal Winding Co., Cranston, R. I., by James A. Shephard.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

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Erie, Pennsylvania
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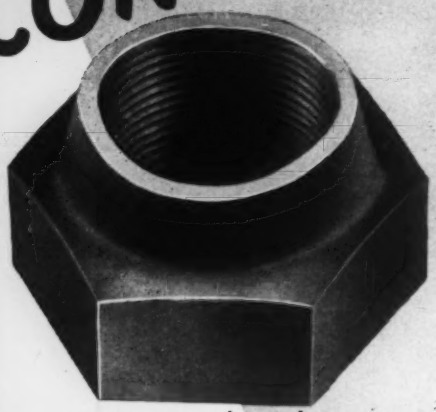
NEW CONELOK



one-piece locknut . . .
with prevailing torque

Three sectors of the tapered portion of the CONELOK nut are preformed inwardly (Fig. 1). When the Nut is applied to a bolt, these conforming sectors are elastically returned to a circular configuration and create an inward and downward pressure which produces intimate contact between the load carrying flanks of the nut and bolt threads (Fig. 2). The shape of the cone sector displacement insures conformity with the mating bolt and maximum friction contact area. . . . The closed stress path in the locking portion of the nut and the advantageous distribution of locking pressure, produce a locking device of high fatigue life . . . and equivalent locking force is exerted at only a fraction of the stress of any slotted type locknut. CONELOK maintains its locking action through many re-applications. . . . It is adaptable to high, and low torque assemblies . . . to high torque stop-nut applications . . . and may be obtained in sizes from No. 10 to 1½", Full and Thick dimensions are "Standard".

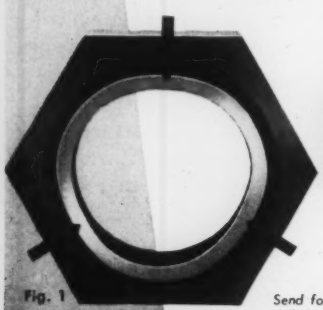


Fig. 1

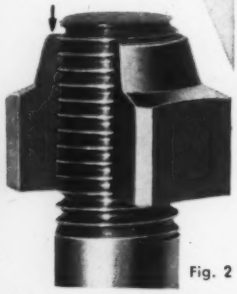


Fig. 2

Send for brochure which includes complete engineering specifications.

NATIONAL MACHINE PRODUCTS COMPANY

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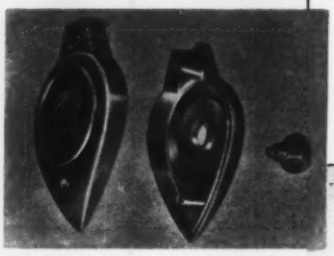
DOLLIN Aluminum Die-Castings

In STANLEY'S New "CHALK-O-MATIC"



meet critical specs for

- Precision fit
- Perfect balance and symmetry
- Fine detail and surface finish
- Low cost

"Chalk-O-Matic," made by Stanley Tools, is a self-chalking chalk line reel and plumb bob in one compact tool. To prevent chalk leakage, both case sections require precision fit. To assure a perfectly balanced plumb bob demands utmost symmetry of each section. Dollin die-castings meet these requirements, plus clean, smooth, sharply defined detail for subsequent finishing. Center hubs are also die-cast by Dollin.

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Sales offices in principal centers
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Our 25th Anniversary

DOLLIN DC
Zinc and Aluminum
DIE-CASTINGS

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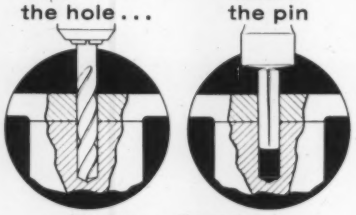
For Fast Assembly...
GILLEN GROOVE PINS
No Reaming



Fast... Secure
Saves Time and Money

3 grooves compress and reform to diameter of hole for tight positive fit . . . no tapping, no threading, no reaming.

Six types, for *many applications*, variety of lengths and diameters, all metals.

Write for information. Ask for samples.

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Keying and Pinning Devices
2568 South 50th Avenue • Cicero 50, Illinois
A Subsidiary of Standard Railway Equipment Manufacturing Company

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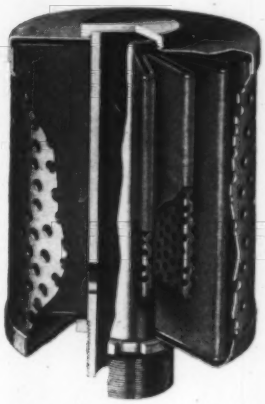
for hydraulic and lube oil systems



● Screen wire mesh reinforced by pleated perforated metal provides greatly extended filtering area. This results in lower pressure drop, larger dirt capacity. Entire unit protected by perforated cover to prevent accidental damage. A wide choice of bronze, monel, or stainless media provides various degrees of positive filtration. Capacities from 1 to 100 gpm, male or female connection. Write for Specification Sheet OCO-1057. **AIR-MAZE CORPORATION**, Cleveland 28, Ohio. Dept. MD-3.

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MAC

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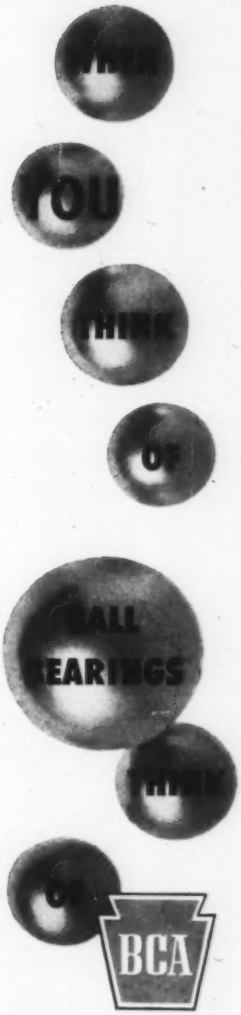

Concentration on design and production of quality ball bearings for all kinds of uses over a 50-year period has taught us a lot. Like how to move fast when sudden new engineering needs arise. How to keep production flexible when everybody wants everything right now. How much worth there is—to our customers and to us—in pride of workmanship and real understanding of a supplier's duty to meet "when-promised" delivery dates. If things like this make sense to you, talk to us about your ball bearing requirements, whatever they may be. Bearings Company of America Division, Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA BALL BEARINGS

BEARINGS COMPANY OF AMERICA

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Pamarco offers complete service on light or heavy duty precision cylindrical components. Large quantities for production or parts for maintenance. Rolls, shafts, axles and other cylindrical parts to closest tolerances. Chrome, copper and pentrate finishing, slab milling, long keyways. Eliminate production bottlenecks with Pamarco high-accuracy cylindrical parts!

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JUST LIFT THE SEAT

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Three Sizes
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... CONTAINS DATA ON WIDE SELECTION OF FLOW DEVICES SUCH AS:

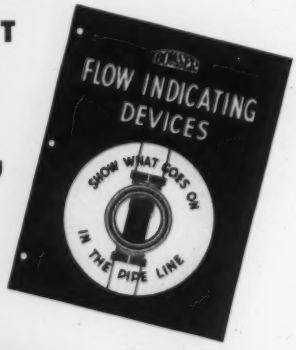

Fig. 54A Flow Sight

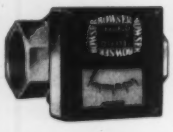
Fig. 816 Teleflo Indicator

Fig. 811 Flow Indicator

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PRODUCT OF BOWSER RESEARCH

WRITE FOR FLOW DEVICES BOOKLET } Contains Complete Specifications

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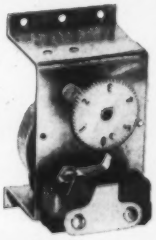
Instant Fingertip Setting... For 0 to 120 Second Delays



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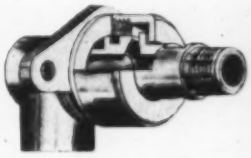
CONDITIONS TOO SEVERE
FOR
ORDINARY REVOLVING JOINTS?

AIR-STEAM-VACUUM-HYDRAULIC-OXYGEN
WITH AS MANY AS 4 PASSAGES

MANY ROTHERM REVOLVING JOINTS OPERATING UNDER THE FOLLOWING CONDITIONS



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PROOF OF PERFORMANCE AT 10,000 HRS.

LET US SOLVE YOUR JOINT PROBLEMS.

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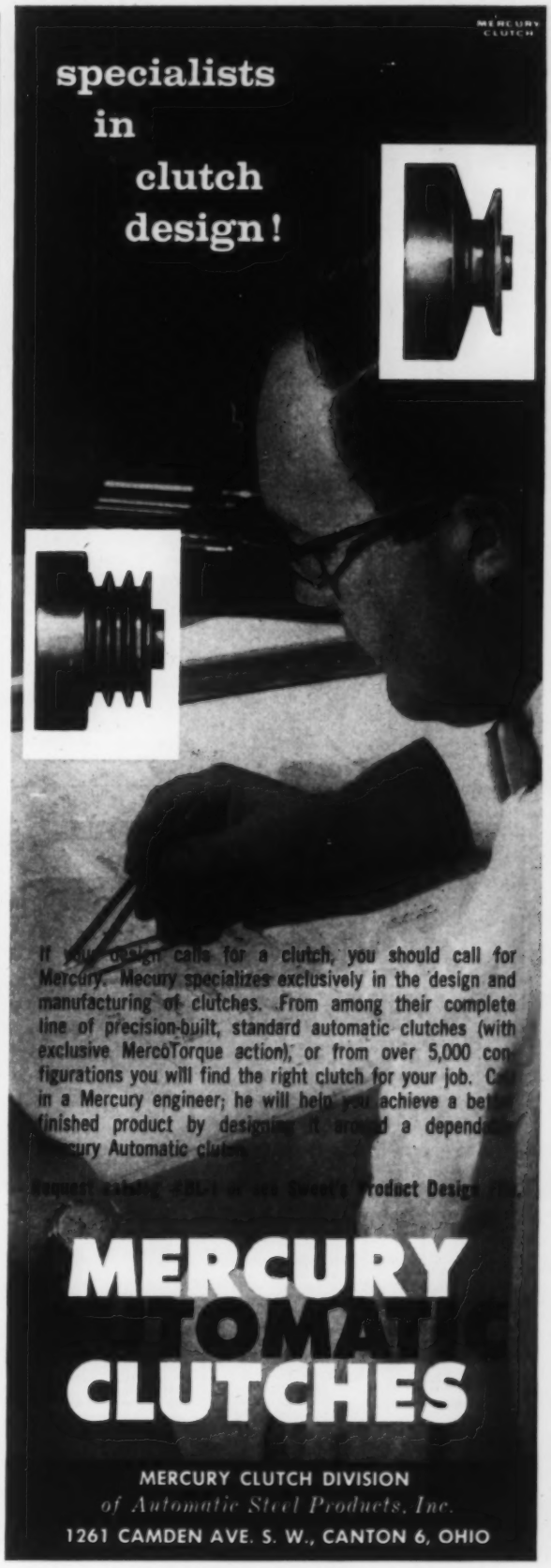
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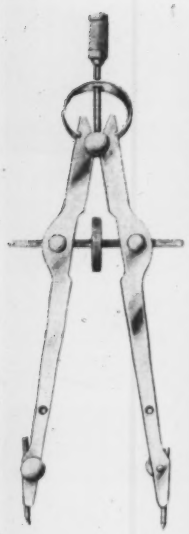

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VEMCO

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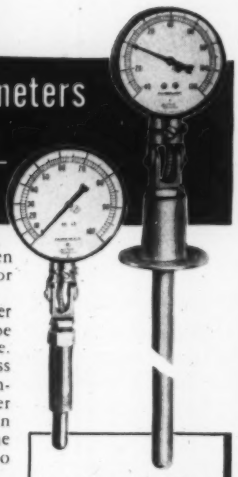
New!

Marsh Dial Thermometers *designed expressly* for piping and ducts



Here you have everything that has been so long needed in thermometers for piping and duct work.

Big 3½" and 4½" dials are far easier to read; still more important, can be turned and tilted to *any* reading angle.

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Complete line provides for every service. Separable sockets and swivel attachment nuts make connecting and disconnecting easy. Extension necks provide for insulated piping and ducts.

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Ranges: 0°—100° F, 20°—120° F, 40°—240° F and 100°—300° F. ¾" NPT male connection.

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Ranges: minus 40°—120° F, 0°—160° F, 0°—220° F. Long stems extend into ducts for accurate indication.

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New bulletin covers interesting details

Jas. P. Marsh Corporation
Dept. B. Skokie, Illinois

MARSH

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Life Saver size - only 7/16"x ¾"

Renbrandt offers a complete line of ultra-compact, precision-made couplings featuring *zero backlash, low inertia and high flexibility*.

Typical is the newest shown above which is Life Saver size. Specifications: bores in any diameter from $\frac{1}{16}$" through $\frac{3}{8}$", compensates for misalignments of ±5° angular and ±.015" linear, torque 30 inch ounces, weight .19 ounce, moment of inertia as low as .006 ounce inches², materials and finishes to applicable government or MIL specs.

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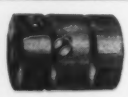

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Low cost for general application. Thousands of uses. ½" dia. x 1½" long. For ¼" and/or ⅜" shafts. No backlash. Insulating nylon center piece.

Send for catalog or send your requirements for quotes. Prompt delivery.

Renbrandt

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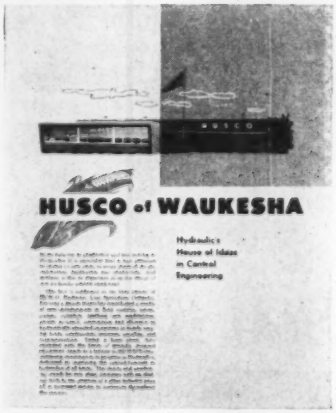

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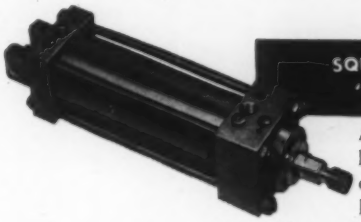

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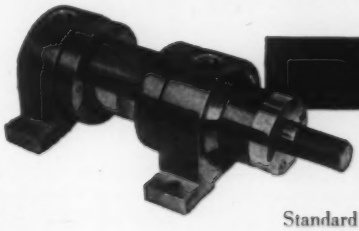

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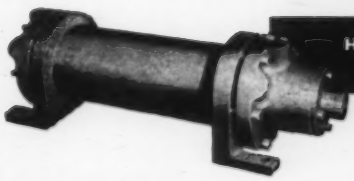

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TEER, WICKWIRE & CO.
1877 WILDWOOD AVE., JACKSON, MICHIGAN

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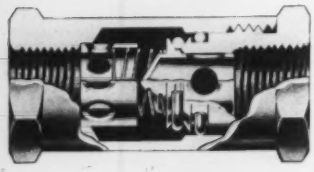

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Circle Seal

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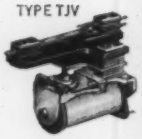

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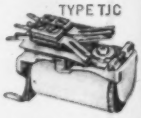

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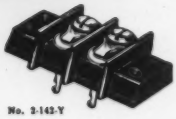

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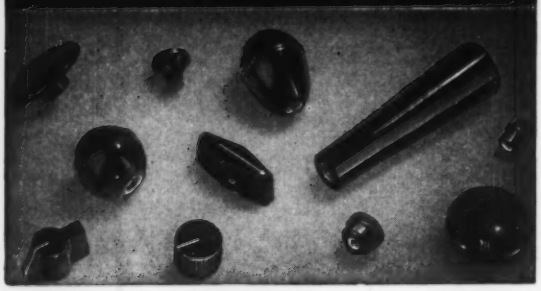

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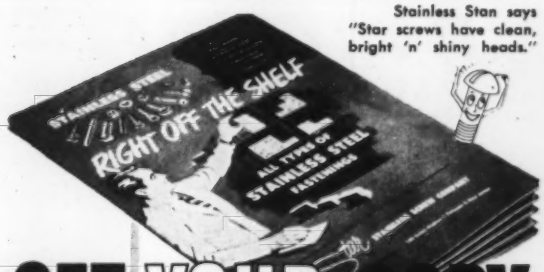

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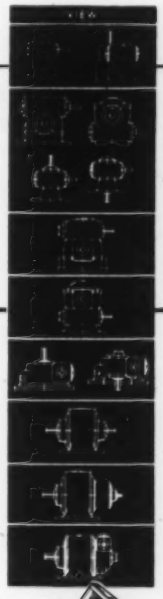

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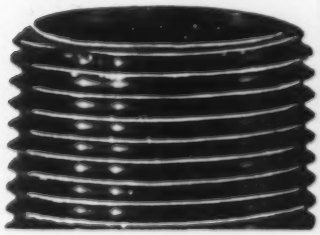

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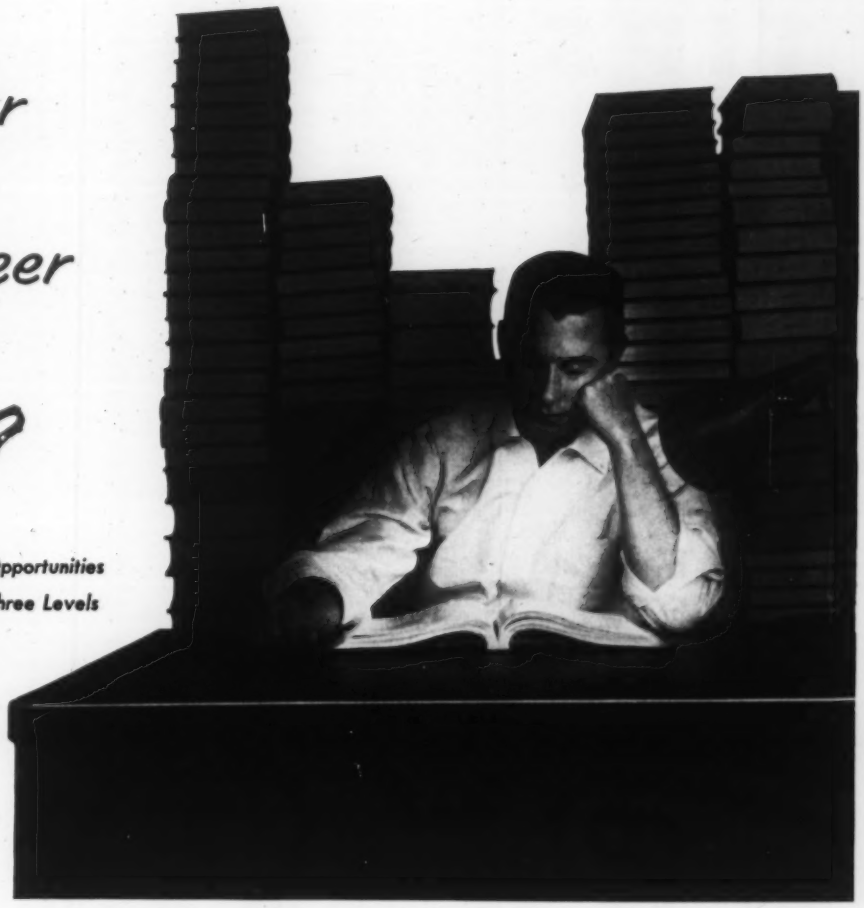

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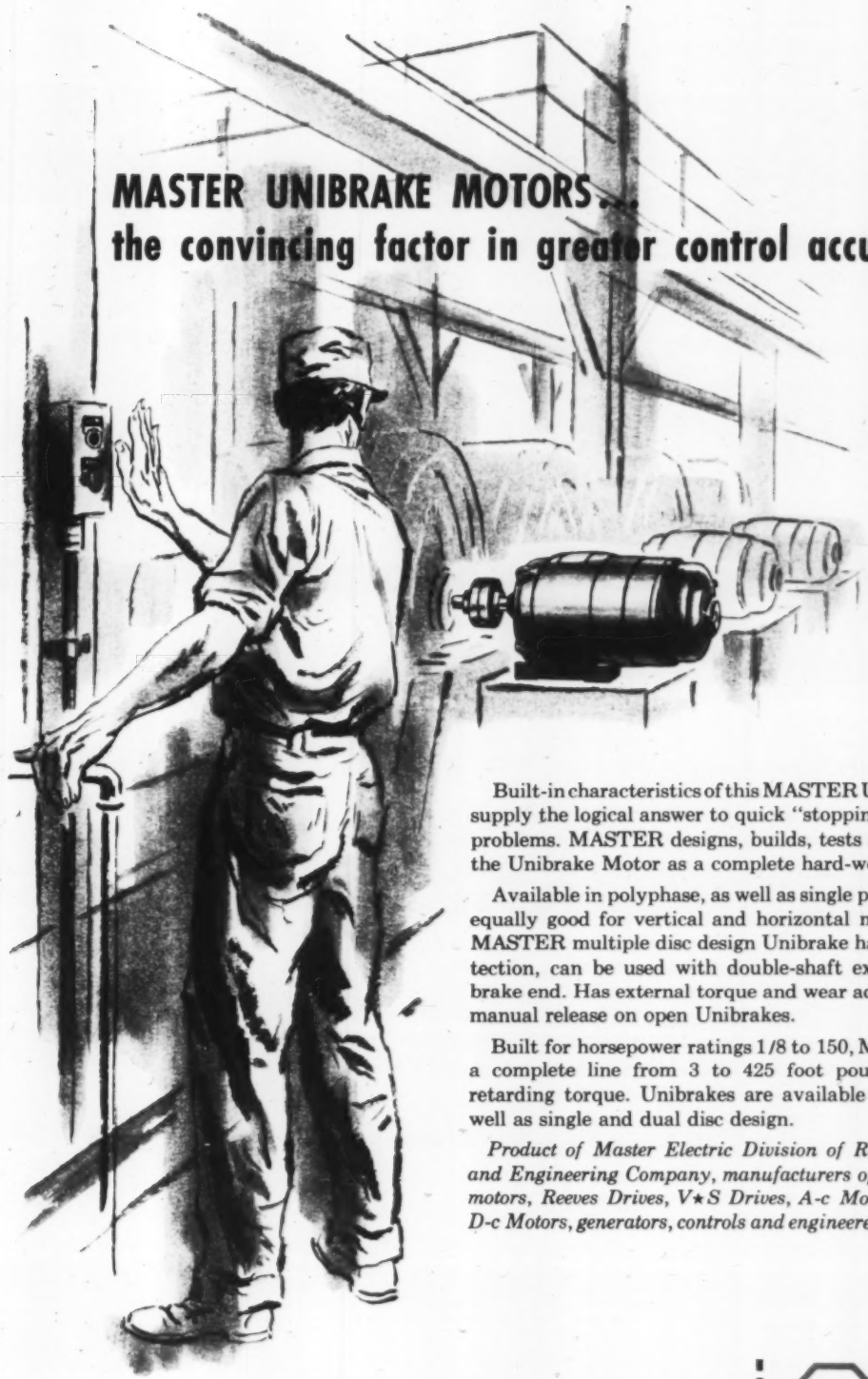

Built-in characteristics of this MASTER Unibrake Motor supply the logical answer to quick "stopping and holding" problems. MASTER designs, builds, tests and guarantees the Unibrake Motor as a complete hard-working *unit.*

Available in polyphase, as well as single phase and d-c.—equally good for vertical and horizontal mounting—this MASTER multiple disc design Unibrake has fail-safe protection, can be used with double-shaft extension at the brake end. Has external torque and wear adjustment, plus manual release on open Unibrakes.

Built for horsepower ratings 1/8 to 150, MASTER offers a complete line from 3 to 425 foot pounds maximum retarding torque. Unibrakes are available in multiple as well as single and dual disc design.

Product of Master Electric Division of Reliance Electric and Engineering Company, manufacturers of Master Gearmotors, Reeves Drives, V★S Drives, A-c Motors, Super 'T' D-c Motors, generators, controls and engineered drive systems.

B-1614

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 283A, CLEVELAND 17, OHIO
CANADIAN DIVISION: TORONTO, ONTARIO
Sales Offices and Distributors in Principal Cities

MASTER REEVES R

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3 new applications get longer life and minimum maintenance using Dodge pillow blocks with Timken® bearings

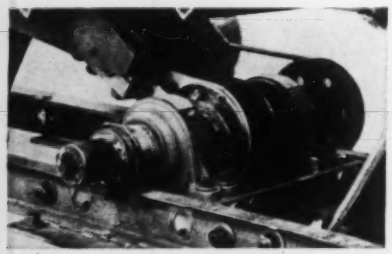
PICTURED below are three applications where Timken bearing equipped Dodge pillow blocks stay on the job with little attention under tough conditions. Their tapered design lets Timken® bearings take *both* radial and thrust loads in any combination. And full-line contact between rollers and races provides extra load-carrying capacity. Wear is reduced, maintenance is cut to the minimum.

Cutaway view shows the Dodge All-Steel pillow block with Timken bearing mounting. Of special design, the bearing has a tapered bore with self-aligning spherical outer surface —never needs adjustment.

Besides the All-Steel pillow block, other versatile Dodge pillow blocks with Timken tapered roller bearings are: Type "E", Double-Interlock, Type "C" and Special Duty. All are compact in design. Special thrust devices that take up extra space are not needed.

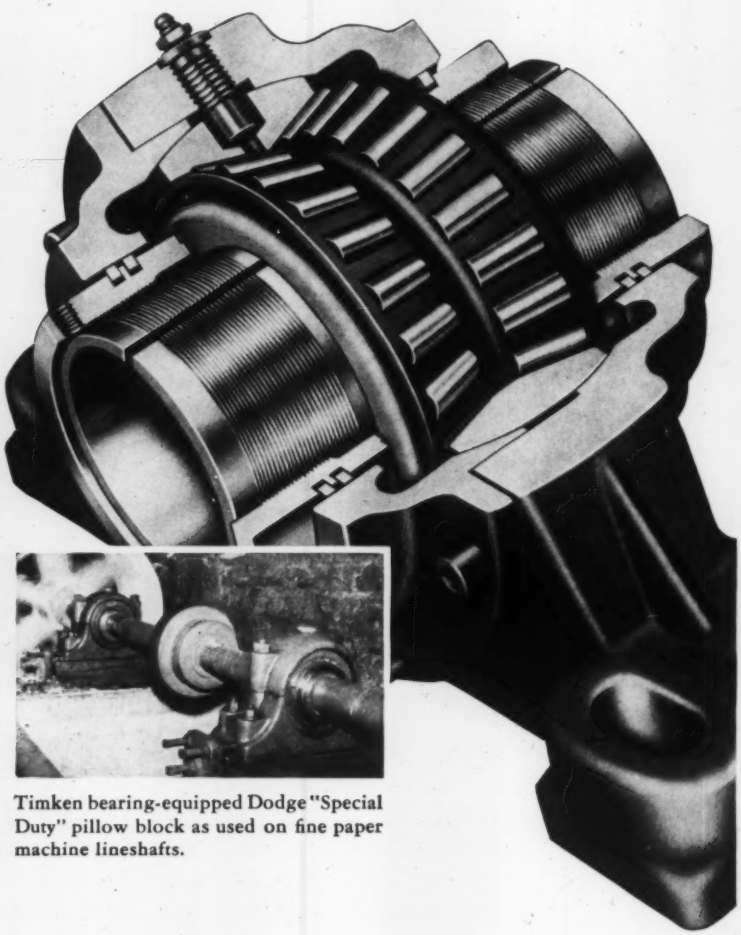
And to get the finest steel for Timken bearings, we make it ourselves—America's only bearing manufacturer that does. So specify bearings trademarked "TIMKEN" for the machines you buy or build. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



Timken bearing-equipped Dodge All-Steel pillow block used in a vibrating conveyor.

Timken bearing-equipped Dodge Type "E" pillow block used in sand and gravel plant.



Timken bearing-equipped Dodge "Special Duty" pillow block as used on fine paper machine lineshafts.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD

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